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An Enhanced Synthetic Environment for Maritime Surveillance

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Abstract

The Future Forces Synthetic Environments (FFSE) and the Radar and Application Space Technology (RAST) Sections made a joint effort to overcome some limitations associated with the Synthetic Environment (SE) employed during the mission rehearsal, in June 2004, for the Atlantic Littoral Intelligence Surveillance Reconnaissance Experiment (ALIX). During ALIX experiment, the fidelity of the different vessels was deficient, the realism of the sensors was poor and the accuracy of the generated contact reports was incomplete. The realism and fidelity of the merchant and fishing traffic within the synthetic environment was improved. The realism of the sensors within the synthetic environment was increased. The accuracy of the generated contact reports was improved.

This document provides a summary of the achievements of the current task as well as a list of lessons learned and recommendations for organizational and process changes within the FFSE section. Based on the work accomplished in the present task, along with the recommendations, a complete maritime synthetic environment, supporting continuous V&V, for surveillance missions will soon be a reality in the FFSE section

Résumé

Les sections Environnements Synthétiques de Forces du Futur (ESFF) et Application Radar et Technologies de l’Espace (ARTA) ont joins leurs efforts pour surmonter quelques limitations liées à l'environnement synthétique (ES) utilisé pendant la répétition de mission du mois de juin 2004, pour les expériences d’ALIX. Pendant l'expérience d'ALIX, la fidélité des différents navires était déficiente, le réalisme des sondes était pauvre et l'exactitude des rapports de contact produits était imprécise. Le réalisme et la fidélité du trafic marchand et de pêche dans l'environnement synthétique ont été nettement améliorés. Le réalisme des senseurs dans l'environnement synthétique a été augmenté. L'exactitude des rapports produits de contact a aussi été améliorée.

Ce document fournit un sommaire des accomplissements de la présente tâche ainsi qu’une liste de leçons apprises et recommandations pour des changements organisationnels et de processus au sein de la section ESFF. Basé sur le travail accompli dans la présente tâche, tout en tenant compte des diverses recommandations, un environnement synthétique maritime, supportant continuellement V&V, des missions de surveillance sera bientôt une réalité dans la section ESFF.

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Executive summary

The Atlantic Littoral ISR eXperiment (ALIX) was a major east coast Intelligence Surveillance Reconnaissance (ISR) experiment held in late August 2004, involving the use of an uninhabited aerial vehicle (UAV) and other ISR sensors including High Frequency Surface Wave Radar (HFSWR) [14]. Prior to the ALIX experiment, a rehearsal in a synthetic environment was conducted by the FFSE section, on the DRDC Ottawa site. The Radar and Space Technologies (RAST) Section participated in this rehearsal by supplying a Maritime Operations Centre (MOC) using the Global Command and Control System (GCCS) software.

The RAST section recognized that this had potential to support their on-going work with the Multi-Sensor Integration within the Common Operating Environment-Technology Demonstration Program (MUSIC-TDP) that deals with sensor integration, fusion and its impact on operator workload and the quality of the constructed RMP.

However, the SE employed for the ALIX rehearsal was designed for training and mission rehearsal for the UAV, rather than analysis of the processes associated with maritime surveillance in general, hence there were limitations associated with the contact reports generated from the SE due to the following factors:

1. The realism and fidelity of the maritime traffic in the SE was not consistent with what it is normally seen. This was corrected by constructing a database of representative traffic for one twenty-four hour period.

2. Realism of the sensor suite was insufficient, (e.g. “cookie-cutter” High Frequency Surface Wave Radar models were used and sensors such as the Automatic Identification System, ELINT and other airborne platforms were missing). This was corrected by including well, unclassified, sensors in the SE, and modeling some tracking systems and probabilistic detections in the sensor models to increase fidelity.

3. The accuracy of the generated contact reports was also insufficient, e.g. many of the fields in the OTH messages were either incorrect or not populated. This was corrected with a review of the message fields followed by changes to code and standard operating procedure for the human operators in the SE.

It was noted during the execution of this work that the FFSE section is missing some traditional organizational tools, most notably knowledge management and process infrastructure. The following recommendations are made:

1. Increase the modularity in the maritime SE by developing two stand-alone HLA components, a Commercial Traffic Server (CTS) and an East Coast Maritime Sensor Suite (ECMSS) is recommended,

2. Adopt the Carnegie Mellon Capability Maturity Model (CMM),

3. Focus resource and personnel allocation to maximize individual employees time on **single** projects,

4. Provide clear role definitions for all team members, and

5. Increase in the documentation effort across the board.

A complete maritime synthetic environment for surveillance missions, supporting continuous V&V, is envisioned to become a reality in the FFSE section. This must include a set of modular components for such aspects as traffic, weather, and terrain which can be re-used in future, modular, SEs. Both the FFSE and RAST sections are planning to employ the SE developed in the present task in their future analysis of processes within the maritime operations centre and the generation of the recognized maritime picture, as well as in the evaluation of new sensor platforms, and the development of algorithms for autonomous surveillance systems.

Abdellaoui, N., Hubbard, P. and Duncan P. 2005. *An Enhanced Synthetic Environment for Maritime Missions*. DRDC Ottawa TM 2005-143. Defence R&D Canada – Ottawa.

Sommaire

L’exercice ALIX, tenue en août 2004, était une importante expérience en termes de reconnaissance, surveillance et intelligence de la côte. Cet exercice impliquait l'utilisation d'un véhicule aérien inhabité (UAV) et d'autres sondes ISR comprenant, entre autres, le radar (HFSWR). Avant l'exercice ALIX, une répétition dans un environnement synthétique (ES) a été conduite par la section ESFA. La section Application de Radar et Technologies d'Espace (ARTA) a participé à cette répétition en fournissant un centre d'opérations maritimes employant le logiciel (GCCS).

La section ARTA a identifié le potentiel du ES pour soutenir leur travail en cours avec le projet (MUSIC-TDP) traitant l'intégration de senseur, la fusion des données et l’impact sur la charge de travail de l'opérateur ainsi que la qualité de l’image RMP construite.

Cependant, l’ES utilisé pour la répétition d'ALIX a été conçu pour la formation et la répétition de mission pour l'UAV, plutôt que l'analyse des processus associés à la surveillance maritime en général, par conséquent il y avait des limitations liées aux rapports de contact de l’ES dues aux facteurs suivants:

1. Le réalisme et la fidélité du trafic maritime dans l’ES n'étaient pas très conformes à la réalité. Ceci a été corrigé en construisant une base de données avec du trafic représentatif pour une période de vingt-quatre d'heure.

2. Le réalisme des senseurs était insuffisant (par exemple, le modèle coupe-biscuit pour le HFSWR, senseurs manquants tel le Système d’Identification Automatique (AIS), Intelligence Électronique (ELINT) ainsi que d'autres plateformes aéroportées). Ceci a été corrigé en incluant dans l’ES, tout les senseurs connus et non classifiés; ainsi qu’en modélisant quelques systèmes de pistage et détections probabilistes dans les modèles des senseurs afin d'augmenter la fidélité.

3. L'exactitude des OTH-Gold rapports de contact produits, était également insuffisante, par exemple plusieurs parties des messages OTH étaient incorrectes ou même vides. Ceci a été corrigé avec un examen de toutes les données de message suivis des changements au code et à la procédure d'opération pour les opérateurs dans l’ES.

La section ESFF manque quelques outils d'organisation, notamment en gestion de la connaissance et en infrastructure de processus. Les recommandations suivantes sont ainsi faites:

1. pour augmenter la modularité dans l’ES maritime, le développement de deux composants HLA autonomes, un serveur du trafic commercial (CTS) et une suite de senseurs maritime de la côte est (ECMSS), est recommandé,

2. l'adoption du modèle de maturité des potentiels (CMM) de Carnegie Mellon,

3. attribution plus focalisée de personnel pour maximiser le temps alloué aux différents projets,

4. définitions précises des rôles et tâches des différents membres d'équipe, et

5. une augmentation de l'effort de documentation à travers les différentes phases du projet.

Un environnement synthétique maritime complet et supportant V&V pour des missions de surveillance sera bientôt une réalité dans la section de l'ESFF. Ceci inclura un ensemble de composants modulaires tells: le trafic, climat (météo), et terrain. Ces composants modulaires peuvent être réutilisés à l'avenir en ES. Les sections de l'ESFF et de l'ARTA projettent d'utiliser l'ES développé dans la présente tâche dans leur future analyse des processus dans les centres d'opérations maritimes et pour la génération de l'image maritime identifiée, ainsi que dans l'évaluation de nouveaux senseurs, et le développement des algorithmes pour les systèmes de surveillance autonomes.

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1. Introduction – Maritime Security

With a coastline close to 250,000 km, an area of responsibility (AOR) of over 11 million square kilometres, and some 1700 ships on a typical day; Canada has an immense challenge in its quest for maritime security [2].

There are many various threats to Canada's maritime security: they include environmental pollution, environment disasters, illegal-fishing, smuggling (humans and drugs), illegal use of the sea bed resources, and even terrorism. The goal of maritime security is to know what is happening and where it is happening in the maritime approaches so a potential asymmetric threat can be diffused instead of reacting to the consequences of such a threat.

Even though Canada has long been recognized as having one of the safest and secure maritime systems in the world; the events of September 11, 2001, prompted the government of Canada (GOC) to take further steps to increase efforts to secure the maritime system [15].

The government has allocated additional funds for marine security to better track vessels operating in Canadian waters, increase surveillance, protect marine infrastructure, and improve domestic and international coordination. Key measures include long-range detection technologies; enhanced screening of ships' passengers and crews; advanced reporting requirements to improve the assessment of potential risks posed by vessels, their passengers and cargo; and measures to intercept vessels of concern before they arrive on our shores [15].

Maritime Surveillance, which is fundamentally the observation and control of the territorial waters, cuts across several areas of naval warfare such as Anti Surface Warfare (ASW), Anti Submarine Warfare (ASuW), Acoustic Warfare (AW), Mine Warfare (MW), Exclusive Economic Zone (EEZ) protection, Search And Rescue (SAR), etc; and encompasses an extensive range of needs and capabilities. The impacts of new technology and/or new strategy upon the crew's workload and manning capabilities cannot be fully realized until after the technology has been installed, or the strategy has been applied. While a novelty may work perfectly in theory, and may perhaps operate appropriately in a lab, its interaction with other systems or with the crew can provide unexpected results. Exercising this novelty in a synthetic environment makes it is possible to address the "What if such and such?" questions. For example, in a synthetic environment, the level of complexity of ground truth can be adjusted according to what is being targeted (developing and testing new information-fusion and decision-aid concepts in support of the RMP or training staff in relevant technologies and methodologies, etc.). Because of the above, SE is being employed more and more in maritime surveillance in Canada and abroad.

1.1 The ALIX trial and the MUSIC TDP

The Atlantic Littoral ISR eXperiment (ALIX) was a major east coast Intelligence Surveillance Reconnaissance (ISR) experiment held in late August 2004, involving the use of an uninhabited aerial vehicle (UAV) and other ISR sensors including High Frequency Surface Wave Radar (HFSWR) [14]. Prior to the ALIX experiment, a rehearsal in a synthetic environment was conducted by the Future Forces Synthetic

Environment (FFSE) section, at the DRDC Ottawa site. The Radar and Space Technologies (RAST) Section participated in this rehearsal by supplying a Maritime Operations Centre (MOC) using the Global Command and Control System (GCCS) software.

The RAST section is currently executing Multi-Sensor Integration within the Common Operating Environment-Technology Demonstration Program (MUSIC-TDP) that deals with sensor integration, data fusion and its impact on operator workload and the quality of the constructed RMP. MUSIC provided basic manual fusion techniques for the Maritime Operations Centre Halifax to use during ALIX. The exercise also established a baseline for RMP generation against which the performance of MUSIC's automated fusion methods can be assessed [4]. The other role of the MOC during this experiment was to generate an RMP based on the contact reports generated by the SE, where data fusion was attempted [5].

ALIX trial authorities have recognized that their data set will be a key product for "after the fact" data fusion research, with MUSIC as one of the primary customers for this post-processing effort. Because ALIX occurred early within the MUSIC project schedule, it was not possible for the TD to demonstrate an automated fusion capability during these experiments. However, the ALIX data set will be important to the TD throughout its life, and during the experiment, the MUSIC team examined basic aspects of fusion and associated operator/system metrics that can be leveraged during the remainder of the TD [14].

1.2 Maritime Operations Centre

There is a common misconception that surveillance and command and control of naval forces are directed by an operations centre. The Maritime Operations Centre has as a primary mandate the task of compiling, updating and managing the Recognized Maritime Picture (RMP). This dynamic product is the collation of all shipping detected, identified and tracked in Canada's sea lanes of approach. The Maritime Operations Centre neither commands nor controls operations but functions as a conduit to deployed forces and outside agencies. It is manned by relatively junior personnel; consequently it has neither the capability nor the delegated authority to provide operational direction other than to relay information to planning authorities and to those senior officers vested with such powers. However, the direction of surveillance, the command and control of operations, and the formulation of emergency responses to emergent crisis situations is the responsibility of the Assistant Chief of Staff Plans and Operations and his staff.

1.3 Recognized Maritime Picture

A plot compiled to depict maritime activity (at least in the naval context) is referred to as a Recognized Maritime Picture, see Figure 1. The term "recognized" is used to indicate that the picture has been evaluated prior to its dissemination. In other words, rather than having stations simply pass data between themselves, there is a central authority to whom data is forwarded for compilation, evaluation and dissemination.

The picture is built from all data sources that can be accessed which relate to maritime traffic in the area of concern. Normally, a data source will frequently provide position and identity information of a given vessel; another source might provide, less frequently, additional data such as the vessel's owner, cargo and other background information. Assembled into the picture, all this data provides an awareness of the volume, location and nature of shipping activity and provides a background for deeper analysis of trends and vulnerabilities. Data sources are identified through actively seeking them out and then collecting and assembling the data in a format suitable for exchange between numerous partners. The recognized maritime picture is compiled by fusing all this information and combining it with reports from naval ships and aircraft in their areas of operations.

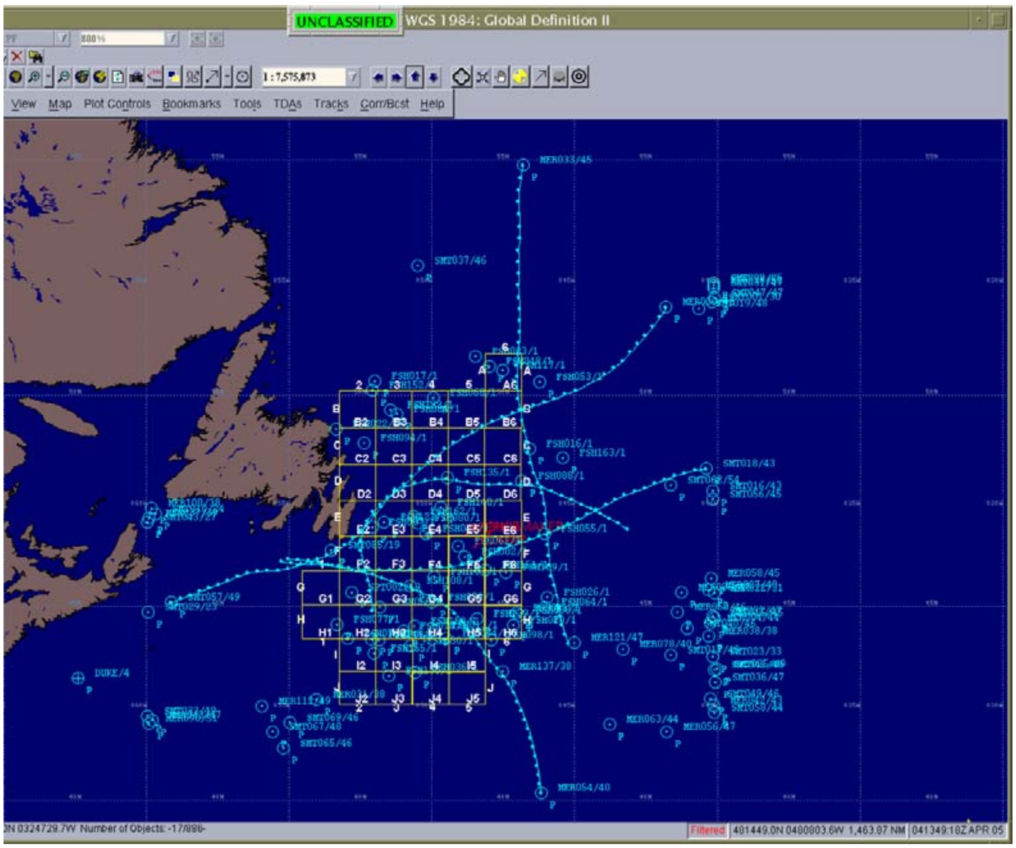

Figure 1. *An example of visualization of the Recognized Maritime Picture with the Global Command and Control System (GCCS).*

The challenge of this process is to create a structure under which all the surveillance data from these systems and platforms is fused together to tell the whole story on each vessel. Surveillance plus intelligence plus fusion equals situational awareness.

1.4 Motivation

The role of the MOC during the ALIX SE work was to generate an RMP based on the contact reports generated by the SE. The following advantages to using a synthetic environment were observed during the SE ALIX rehearsal:

- it created a realistic real-time environment in which RAST section could test out some of their fusion procedures;
- the use of real operators allows them to assess human factors issues; and
- most importantly, the abbreviated nature of the trial could allow them to repeat the trial under different conditions.

The RAST section recognized that SE ALIX had potential to support their on-going work with the MUSIC TDP in dealing with sensor integration, data fusion and its impact on operator workload and the quality of the constructed RMP. However, the SE employed for the ALIX rehearsal was designed for training and mission rehearsal for the UAV mission, rather than analysis of the processes associated with maritime surveillance in general. Hence there were limitations associated with the contact reports generated from the SE due to the following factors:

- The realism and fidelity of the maritime traffic in the SE was not consistent with what it is normally seen.
- The realism of the sensor suite was insufficient, (e.g. “cookie-cutter” High Frequency Surface Wave Radar models used and missing sensors such as the Automatic Identification System, ELectronic INTelligence (ELINT) and other airborne platforms were missing).
- The accuracy of the generated contact reports was also insufficient, e.g. many of the fields in the OTH messages were either incorrect or not populated.
- The Own Ship Weather Messages (OSWEX) messages reported by some merchant vessels to report their locations every 6 hours when in the Open Ocean are not generated.

The ultimate goal of such research program is the development of a modular synthetic environment that can be re-used in other projects, and in particular support capability management [4] of maritime ISR suites. The modularity is key to incremental increases in fidelity or insertion of new technologies. The FFSE section is exploring two federates or servers (which are being studied at FFSE and the exact architecture is being decided) to provide realistic commercial traffic and sensor systems. Other components include a weather server, a visual database, a terrain server, a collaborative development environment, and a portal for experiment participants.

2. Approach

In order to increase the SEs level of realism this project targeted three main areas, maritime traffic levels, Over The Horizon Gold (OTH-Gold) message content and sensor fidelity.

2.1 Maritime Traffic

2.1.1 Task

ALS Consulting was tasked to develop unclassified, realistic maritime traffic data for use in a simulated environment scenario for the generation of OTH Gold formatted message reports.

2.1.2 Deliverable

The deliverable provided was a list of vessel waypoints over a 36-hour period augmented with other vessel characteristics required for the generation of realistic OTH Gold message reports.

2.1.3 Data

Two sources of data were provided to use to develop the maritime traffic data. The first source was a simulation of commercial shipping and fishing traffic derived from and validated against the High Interest Targets (HITs) worldwide vessel-tracking database. The second source was data generated from the ALIX trial. The HITs data, while not containing vessel characteristics, does provide complete track truth in the area. However, the limitations of the HITs data include the following:

- Simulated
- No sensor information
- Data fields incomplete
- Motion not accurate
- Provides data for 72 hour period

The ALIX data represents only actual detections during the exercise time-frame and has the following attributes:

- Actual vessel data

Includes most sensors

Attributes include name, flag, call-sign, course, speed

Provides data for two 12 hour periods with a 12 hour gap in between

Accordingly, the scenario design and data input uses the HITs data to ensure track truth combined with the ALIX data characteristics to generate a realistic output through OTH Gold message reporting. The data sets were validated and combined with other publicly available reference materiel to provide a more complete identification of vessel characteristics within the dataset including class (where applicable), name, type, flag, Ship Control Number (SCONUM), course, speed and time and location.

2.1.4 Data Sources

To develop a realistic scenario CAE modified the software to ensure the following sensor/sources are included in the OTH Gold output:

6. Own Ship Weather Messages (OSWEX)

Merchant vessel self-reporting by message

Reporting frequency every 8-12 hours.

Data includes ship name, call sign, course, speed, and position

7. Automatic Identification System (AIS)

Merchant vessel self-reporting with transponder

Reporting frequency in 1minute intervals Department of Fisheries and Oceans

Data includes name, call sign, course, speed, position, owner, cargo, agent and destination

8. High Frequency Surface Wave Radar (HFSWR)

Provides tracking

Reporting detection every 2-3 minutes

Data includes only positional information

9. Department of Fisheries and Oceans (DFO) AA1

Fishing vessels self-reporting using a transponder

Reporting every 6-10 minutes.

Technical information was provided on capabilities of HFSWR to fine tune the model to ensure realistic detection and tracking. This included information on the detection swath, geographic location of radars, vessel size detection, probability of detection vs. sea state and day and night performance capability.

2.1.5 Vessel Characteristics

All nomenclature used in the dataset is consistent with the ALIX experiment and OTH Gold formatted messages.

Fishing vessels were provided with a simulated motion pattern within the operating area. There are two fishing boat models in STRIVE and they are programmed to each follow a figure-eight pattern with different start headings to give an element of “random” motion.

2.1.6 Scenario

The scenario runs over 36 hours with the first 12 hours providing a historical database for the remaining 24 hours. The scenario comprises 91 entities:

Fish – 37 entities

Merchant – 46 entities

Other – 8 entities

The datasets are attached to this Report.

2.1.7 Scenario Generation Software

To facilitate creation of scenarios based upon maritime traffic data, a scenario generation application was developed. Within the STRIVE synthetic environment, a scenario is a collection of entities, along with related behavioural and geographic information. The scenario generation tool enables the addition of realistic maritime traffic to an existing scenario, or the creation of a new scenario based solely upon the maritime traffic dataset provided. Since behaviour models are required in order to properly enable sensors and generate contact reports, it is anticipated that the most common use of the scenario generator will be to add maritime traffic to a scenario which already contains the appropriate sensor bearing entities, e.g. coastal radar or UAVs.

The input to the scenario generator application is maritime data that has been formatted in Comma Separated Value (CSV) format. Based upon this data the Scenario Generator creates a scenario. It maps the tracks to STRIVE entity types based upon the type of ship and what sensors are present on the vessel. Waypoints are generated

for the ship based upon the track data. Table 1 contains the mapping made between the traffic dataset and STRIVE entities.

Table 1. *Traffic dataset – STRIVE entities Mapping*

Code	***Target Type***	***STRIVE Entity***
DDG	Destroyer, Guided Missile	Krivak frigate
AGB	Icebreaker	Krivak frigate
WAGL	Buoy Tender, Coast Guard	Krivak frigate
TUG	Tug	Generic Ship
BLK	Cargo, Bulk	Container Class
CGO	Cargo, Dry	Container Class
TMB	Merchant Ship, Bulk	Container Class
TMCS	Merchant Ship, Container	Container Class
TMD	Merchant Ship, Dredger	Container Class
TME	Merchant Ship, RO/RO	Container Class
TMF	Merchant Ship, Ferry	Container Class
TMGS	Merchant Ship, Scientific	Container Class
TMK	Merchant Ship, Cable layer	Tanker
TMO	Merchant Ship, Tanker	Tanker
TMOS	Merchant Ship, special liquids	Container Class
FISH	Fisher	Trawler (Blue)
Other	Undefined type defaults to Generic Ship.	Generic Ship

For ships containing sensors, the sensor type is appended to the entity name. For example, a Fisher with an AA1 sensor would be named “Trawler (Blue) AA1”.

A behaviour model is assigned to the entity based upon what equipment is present. If no equipment is present, no behaviour model will be assigned, and the STRIVE entity will follow its default behaviour, which is to follow the assigned waypoints.

For fishing vessels, no track data is present in the original dataset, and a behaviour model is assigned instead which causes them to navigate in a figure-eight pattern around their starting point.

It was not possible to map all of the information present within the maritime traffic dataset in to the corresponding STRIVE entity. For example, STRIVE entity names are limited to 10 characters, so any characters beyond this limit will be lost. There are not general purpose fields in which to store additional information, so it was not possible to store all of the information associated with an entity. Also, within STRIVE, the country associated with an entity type can not be changed, so that the only way to properly map flags would be to create hundreds of entities associated with the permutations of flag and entity type.

This information is present within the AIS sensor model developed by CAE, but is not accessible from within STRIVE Studio. The fields affected are as follows:

HIT ID

Class

Category

Flag

SCONUM

UID

International Radio Call Sign

In order for the Scenario Generation software to operate properly, all of the required entity types and behaviours must be present within the particular instance of STRIVE. To use the software, the following command should be issued from within the c:\FFSE106\bin directory:

```
scenariogenerator <data file> [old scenario] <new scenario>
```

The data file should point to a properly formatted CSV file containing the maritime traffic. The old scenario argument, if present, is the name of the STRIVE Scenario which is used as basis for the new scenario. The new scenario argument is the name of the new scenario to generate. These names should correspond to the name of the STRIVE Scenario as displayed within the STRIVE Studio application. If the name contains spaces, it should be enclosed within quotation marks.

2.1.8 Sub-Banding

The version of STRIVE being used by DRDC Ottawa, STRIVE 1.8.8.0 Beta, could not support the number of entities required for realistic maritime traffic. It was estimated

that it would need to be able to support upwards of 100 entities with sensor models, and the current version was limited to approximately 40 entities.

It was noted that most of the maritime traffic had a quite limited range of behaviour, and so could be updated less frequently than the overall simulation. For example, all of the maritime traffic excluding fishing vessels would simply follow a predefined route for the duration of the simulation. In most cases, these routes consisted of only a few waypoints. In this case, there is no need for the simulation to update the state of these entities as often as it would for a more dynamic entity such as an UAV. By reducing the update rate associated with quasi-static entities, less processing is required for each update of the simulation state, allowing STRIVE to accommodate more entities.

Work was done by CAE to investigate both the limitations of the current version of STRIVE, as well as to develop a sub-banding approach to entity updates, allowing for certain entities to be updated less frequently than others. This work involved replacing the dynamics models of certain entities with newly developed dynamics models which would support a slower update rate.

STRIVE updates dynamics models at a fundamental rate of 40 hertz. This has been sub-divided into 5 bands. The dynamics models for the ships have been set to update in one of these bands, which gives and effective update rate of 8 hertz.

The use of these dynamics models is dependent upon having two environment variables set. These are outlined in Table 2.

Table 2. *Sub-banding Environment variables*

ENVIRONMENT VARIABLE	PURPOSE
CGF_DYNAMICS_SUBBANDING_LEVEL	Must be set to 1 to enable sub-banding.
CGF_SHIP_DYNAMICS_SUBBANDING_LEVEL	Band in which to update.

2.2 OTH-Gold Messages

The second area targeted in order to increase the level of realism was the OTH-Gold messages. Based on message formats provided by DRDC Ottawa taken from the ALIX trial CAE modified the existing OTH-Gold plugin to support the new message formats. This involved modifications to the CgfMdlCom.dll library.

These modifications include the following information:

Adding XCTC format to contact reports.

Adding OSWEX report.

Adding AIS report.

Adding AA1 report.

Adding HFSWR report.

In order for the OTH-GOLD plugin to send messages to a specific location, the GCCS Location environment variables must be set as shown in Table 3.

Table 3. *GCCS Location Environment Variables*

ENVIRONMENT VARIABLE	PURPOSE
GCCSIP	IP Address of the GCCS Computer.
GCCSPort	Port on which to receive OTH-GOLD messages.

The STRIVE exercise should be running before the OTH-GOLD gateway is started. It can be started by means of a batch file, or by the following command:

```
SfxCp –type Sfx::OthGoldGateway
```

2.3 New Sensor Models

2.3.1 HFSWR

The HFSWR model was created by CAE to alter its coverage and sensitivity based on information provided by DRDC-Ottawa. The new area of coverage is a 120 degree cone with a minimum detection range of 50 nautical miles and the maximum detection range of 220 nautical miles. The probability of detection changes from 100% detection at the center of the cone coverage to 20% probability of detection at the edge of the cone.

Probability of detection is also affected by time of day based upon either day or night time conditions. Day is considered to last from 6am to 6pm. Under night time conditions the effective range of the target is increased by 30 nautical miles. The probability of detection is dependent on the range of the target, as well as its orientation with respect to the radar.

The HFSWR uses the visual contrast of the target to compute its Radar Cross Section (RCS). However, it is necessary for the target to have a RCS value, even though the HFSWR model does not make use of it, in order for it to be considered a radar target.

2.3.2 AIS

An AIS sensor was also added to the STRIVE setup by CAE. The AIS sensor consists of two parts, a transmitter on the vessels and a transmitter on the aircraft. The aircraft with the transmitter requires a rule set to look for vessels with an AIS transmitter and generate contact reports for them. The AIS transmitter on the vessels contains extra information not normally associated with the STRIVE entity that is needed to generate the AIS contact report. This includes vessel class, type, category, call sign and flag. In order for the line of sight calculation to work correctly for the AIS receiver/transmitter, the entity must be located in a part of the world covered by the terrain database.

2.3.3 AA1

An AA1 sensor was also added to the STRIVE setup by CAE. The AA1 sensor consists of two parts, a transmitter on the vessels and a transmitter on the aircraft. The aircraft with the transmitter requires a rule set to look for vessels with an AA1 transmitter and generate contact reports for them. In order for the line of sight calculation to work correctly for the AA1 receiver/transmitter, the entity must be located in a part of the world covered by the terrain database.

2.3.4 Doctrines for the New Sensors

In order for the HFSWR, AIS, AA1 and OSWEX contact reports to be generated the appropriate doctrines must be attached to the appropriate STRIVE entities. Copies of these doctrines are included in the appendices. The HFSWR entity requires “An HFSWR Report” doctrine in order to generate OTH-Gold messages. Any entity equipped with an AIS or an AA1 transmitter/receiver requires “An AIS Report” or “An AA1 Report” Doctrine. Similarly, entities that are supposed to generate OSWEX reports require “An OSWEX Report” doctrine.

2.3.5 Entity Modification for New Sensors

In order for entities to be perceived as having an AIS or an AA1 transponder the entities frame must have the following additional information added to its frame in the associated INI specimen file.

```
component = Ship log signature
  Ship Class           = CONTAINER
  Ship Type            = SHIP
  Ship Category        = MER
  Ship Country Flag    = CA
  Ship Pennant Number  = NC1234
end
```

3. Results

Like in any other project where the results are measured by the hits and misses, this task is no exception. This task scored well on some issues and scored below average on others as detailed in what follows.

3.1 Realism and Fidelity of Maritime Traffic

Realistic data was obtained about typical levels of maritime traffic present within the area to be simulated.

The data for maritime traffic was obtained from the High Interest Targets (HITS) database and a Scenario Generation application was developed in order to insert entities into existing STRIVE Scenarios based upon this data. There is a limitation in STRIVE in terms of number of entities that can be handled correctly without degrading the performance. The number of entities is related to the computer's computation's power and to the interaction of these different entities with the environment; in a typical situation similar to the current project's scenarios, this number is thirty to forty. Unfortunately, the number of entities for this task's scenarios is over a hundred. In order to accommodate more entities within the synthetic environment, a sub-banding dynamics model was developed for all of the slow moving entities, i.e. the ships present within the simulation.

3.2 Realism of Sensor Suite

The realism of the sensor suite was slightly enhanced by updating the existing HFSWR sensor model to more accurately reflect the coverage of this radar, but this sensor model is still not accurate regarding the detection algorithm.

In addition, AIS receiver/transponder sensor models were added to the simulation and attached to some vessels.

The concern about the sensors model, that is using a "cookie-cutter" approach, is still outstanding and nothing is done about within this project.

3.3 Accuracy of Contact Reports

Following guidance given by DRDC Ottawa technical authorities the formatting of the contact reports was revised in order to generate realistic contact reports. This involved changing the formatting of some of the fields of the OTH Gold messages, as well as populating some fields which were previously left unpopulated.

It was also necessary to add an OSWEX (Own-ship Weather) model to the simulation to generate additional positional information.

4. Recommendations

4.1 External Maritime Traffic Federate

As part of the current task, STRIVE was modified to support sub-banding of the update rate of some vessels, in an effort to increase the number of entities which can be successfully simulated within STRIVE. Although further work could be pursued along these lines, it would also be desirable to investigate off-loading some of the processing from STRIVE by the creation of an external federate to simulate maritime traffic.

Given the nature of the maritime traffic, course changes seldom occur over the 36 hour period considered. Because of this, it is not necessary to update the state of the simulated entities as often as would happen by default within STRIVE. Also, high fidelity dynamics and behavioural models are not presently required. Because of this, the entities associated with maritime traffic could be removed from STRIVE, and simulated within an external HLA federate.

The advantages of this approach would be greater control over the frequency at which the entities update within STRIVE, as well as the possibility of moving the maritime traffic simulation to another computer, removing processing load from the STRIVE computer.

There are some risks associated with this approach. In order to interoperate with the UAV RTB in its current condition, it would be necessary to develop a federate which will interact with STRIVE via the CAE RTI. It is not certain that the CAE RTI would be able to handle the level of traffic associated with moving all of the maritime traffic to another computer.

If it is not necessary to interoperate with the UAV RTB, then the application could be simplified, as it would only need to generate properly formatted OTH-Gold messages. In this case, rudimentary sensor and communication models would need to be developed in order to generate the proper OTH-Gold messages at appropriate times.

4.2 OTH-Gold Message Router

In the current simulation set up, all OTH-Gold messages generated within STRIVE are sent on the STRIVE RealGccs communication channel which then forwards the messages immediately to the GCCS machine. This is not desirable behaviour for some message types. For example, AA1 reports are produced every 6 - 7 minutes by each vessel equipped with a transponder, but the messages are supposed to be collected and sent as a group every 12 hours.

In order to simulate this behaviour, it would be desirable to add an OTH-Gold message router which would act as an intermediary between STRIVE and the GCCS machine. The STRIVE exercise variables would be modified to point to this router. The router

would sort OTH-Gold message depending upon their type, forwarding some of them immediately to the GCCS machine, and collecting others for later transmission, as appropriate.

4.3 Sensor Model Improvements

This task was intended to create a scenario using realistic maritime traffic data, and to demonstrate the scenario working in the RTB with existing sensor models. As part of the work in this task, it was decided to improve the characteristics of the existing models, as previously described. This section will outline potential additional sensor models and will recommend priorities for future development.

4.3.1 Data Flow Network

To ensure an understanding of the data flow within this scenario, Figure 2 shows the Maritime Operations Centre and associated information sources and networks:

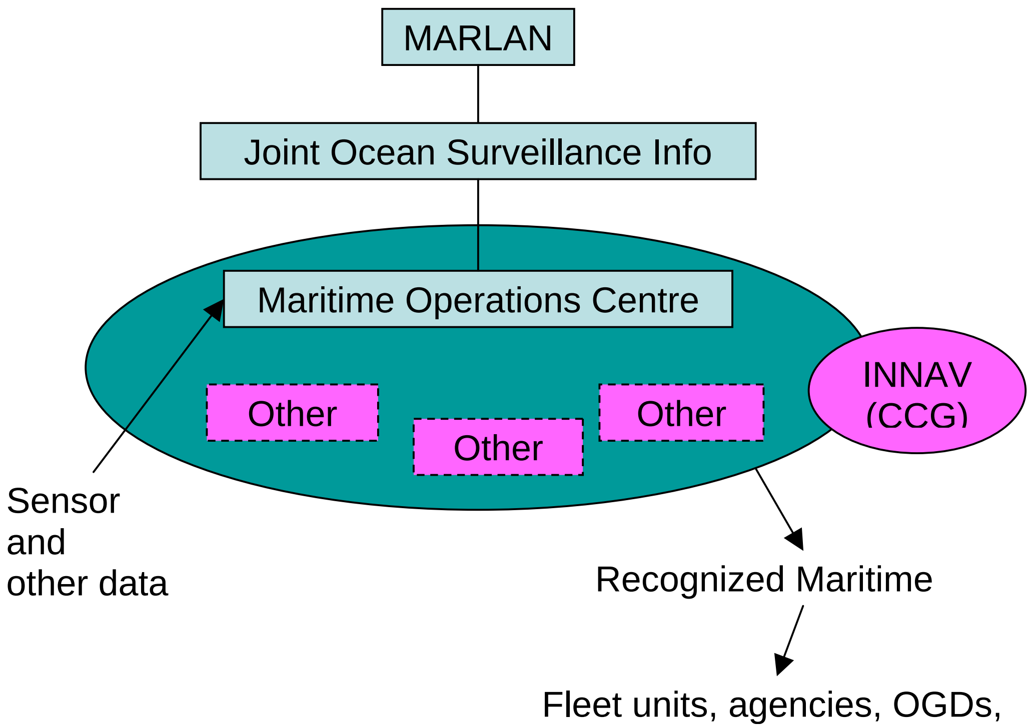

Figure 2. *MOC and Information Sources & Networks*

4.3.2 Information Sources

The following section describes sources of information on maritime traffic in the relevant area off-shore eastern Canada, and notes which of the information sources were modeled in the present task.

4.3.2.1 Merchant vessel OSWEX

Some merchant vessels around the world report Own Ship Weather Messages (OSWEX) and their locations every 6 hours when in the open ocean. The purpose of these messages has been to monitor weather conditions throughout the world to consolidate and provide a weather service to mariners; however the data includes ship name, call-sign, course, speed, and position. OSWEX messages are sent by e-mail to CANMARNET, where they are automatically translated into GOLD format and forwarded to GCCS-M with no MOC operator involvement.

The OSWEX messages were included in the scenario as part of the present task.

4.3.2.2 Canadian Coast Guard INNAV

The Information System on Marine Navigation (INNAV) system manages communications from merchant vessels, which must report by radio or email to Canadian Coast Guard (CCG) shore stations 96 hours prior to arriving at Canadian ports. The data includes ship name, call-sign, course, speed, position, owner, cargo, agent, and destination. A dedicated INNAV server within TRINITY facilitates full-time exchange between CCG and DND.

The CCG messages were not deemed relevant to the present task scenario, due to the relatively short duration of the scenario.

4.3.2.3 Maritime Surveillance Aircraft

Maritime surveillance aircraft provide visual identification and confirmation of contacts. Sea King helicopters are infrequent sources of contacts; CP-140 Aurora maritime patrol aircraft typically conduct one or two surveillance flights weekly. Contact information includes name, call-sign, classification, position, course, and speed. Contacts are not always available until the aircraft has landed and post mission results are forwarded to the MOC, where they are read and translated by GCCS-M; however, the CP-140 can send messages to Greenwood via Link-11 HF radio transmission, which are then forwarded to GCCS-M. The MOC can also communicate by AGA radio directly to the CP-140 to supplement Link-11 data in near real time.

The scenario in the present task called for creation of appropriate maritime traffic, so maritime surveillance aircraft were not modeled.

4.3.2.4 Canadian Naval Ships at Sea

These ships generally report their own position at least hourly via GCCS-M. They also report positional information on vessels in their vicinity on an opportunity basis and

may conduct courtesy hails to acquire more information (Civilian ships are not required to provide information in response to courtesy hails, but normally do). Reports are sent every 24 hours, and include name, call-sign, course, speed, position, and activity once every 24 hours.

CF ships were not included in the current task.

4.3.2.5 Provincial Airlines (PAL)

The Department of Fisheries and Oceans (DFO) contracts PAL to conduct fisheries patrols on a regular basis using commercial aircraft. One to three flights are conducted daily around the fishing grounds off Newfoundland and Nova Scotia. PAL aircraft link with their own shore bases, and the MOC taps into these reports via the Surveillance Information Server (SIS). The information arrives in the MOC about 15 minutes time late. An MOU is under negotiation that would allow the Navy increased ability to task a PAL flight to find/track a specific target. The PAL flights are equipped with search radar, AIS receiver, and EO sensors, and data includes ship name, call-sign, course, speed, and position.

The PAL flights were not included in the current scenario.

4.3.2.6 High Frequency Surface Wave Radar (HFSWR)

HRSWR is a Technology Demonstration which provides track information to the MOC where it is translated into GOLD format for GCCS-M. The connectivity and data availability of HFSWR has been intermittent given that the system is not an operational capability and MOC watch keepers are therefore not responsible to ensure connectivity is maintained. HFSWR tracks provide only positional but no ID information, resulting in a large number of “unknown” tracks. An NDHQ capital project intends to bring the existing demonstrator sites to operational status and provide several more.

This capability was modeled in the current task.

4.3.2.7 Automatic Information System (AIS) transponders

These are currently fitted on ships greater than 300 tons, and are becoming increasingly prevalent as the worldwide regulatory scheme regarding AIS carriage is progressively implemented. The transponders report at one-minute intervals, and information includes Data includes name, type, position, course, speed, navigational status and other safety related data. Most AIS-based reports received by MOC are from the CCG INNAV system, as CCG has the mandate to collect the information.

The AIS receiver was modeled in the current task.

4.3.2.8 Electronic Intelligence (ELINT)

ELINT primarily provides information on concentrated areas of radar activity. It can indicate where there is a high level of radar saturation, such as for a fishing fleet. This

resource could track a specific vessel in the form of an Area of Probability providing that its unique radar characteristics have been fingerprinted. This may be difficult to achieve for civilian vessels, which frequently lease their radars and switch them routinely. This system is classified, and the characteristics, data content, and deployment are unknown.

This capability was not included in the current task.

4.3.2.9 DFO AA1

Certain fishing vessels, above a certain size, in the North Atlantic are required to carry transponders. The DFO makes this information available to DND. Reports are typically forwarded to DFO as block reports (several hours worth), comprised of vessel positions taken at regular intervals (i.e. 6 to 10 minutes). The DFO forwards this information to DND every 12 hours.

The provision of this information was not included in the current task.

4.3.2.10 Coast Guard Fax

The CCG still reports the locations of its ships via a daily fax to the MOC. The data in the fax is typically current within one or two hours when sent. However, it may take over an hour to manually enter the data into the GCCS-M.

This was not included in the current task.

4.3.2.11 Commercial EO Satellites

DSpaceD project Polar Epsilon, currently in Options Analysis, is exploring ways to use current and future commercial EO satellites [e.g. optical satellites and RADARSAT-2] in support of maritime surveillance. RADARSAT-2 would be useful for wide-area detection of ships that are not emitting and hence would otherwise go undetected. Optical satellites would provide high resolution imagery that would be useful for analysis and classification.

This was not included in the current task.

4.3.2.12 Uninhabited Aerial Vehicles (UAVs)

Research, including annual trials, is currently underway to determine CONOPS and operational utility of UAVs as maritime surveillance assets, including the ALIX trials recently conducted in real and simulated environments. UAVs would be equipped with sensor systems similar to those on PAL flights, including a search radar, AIS receiver, and EO sensors.

The RTB includes a UAV simulation, in the current task the transfer of OTH gold messages depended on creation of custom software for the interface. As this was not part of the current task, this software could be created later.

4.3.2.13 US Office of Naval Intelligence (ONI)

The ONI sends locator messages to TRINITY on various vessels based on criteria defined by ONI and only partially released to Canada. These will include vessels on a Vessel of Interest (VOI) list, but also some that are not on this list.

4.3.2.14 Transport Canada – CG-300 Pollution Surveillance Aircraft

The MOC receives a CG-300 Pollution Surveillance Aircraft Fax from Transport Canada. The fax provides the SDO with vessel names, positions, ports, vessel types, times and dates. The information is manually entered into GCCS-M.

Not included in the current task.

4.3.2.15 ECAREG (Eastern Canada Traffic Regulatory System)

The ECAREG Active Vessel List fax is a hard copy of emails that the SDO receives throughout the day from ECAREG in Dartmouth. This fax is automatically converted into GOLD format to be processed by GCCS-M.

Not included in the current task.

4.3.3 Priority of Future Model Improvements

In determining which sources of information should have priority for future modeling, it is important to consider several factors:

10. The number of contacts that the source will provide. This will be based on the reporting frequency and on the number of different vessels on which the source would be expected to report.

11. The accuracy of the source, in terms of the absolute position of the contact.

12. The amount of information contained in the reports.

13. The timeliness of the information, ie, how long after the detection is the information reported to the MOC?

14. The difficulty in modeling the source. This will be significantly affected by the required interaction with other entities in the scenario. For example, a radar model would have to interact with another entity, and via a set of rules determine if that entity should be reported; on the other hand, an own-ship reporting capability model would simply create an appropriate message at a regular time. The radar model would also be more difficult to create to an appropriate level of fidelity.

4.3.4 Time Line Analysis

Figure 3 shows a four-day time-line, representative of a possible future scenario in the RTB. The time line shows how frequently a single vessel in the Area of Interest could be expected to be reported to the MOC by the various sources (those sources with time-line information). This figure clearly shows that the Navy own ship, HFSWR, and AIS transponders provide close to continuous reporting of position, and that OSWEX, PAL, and DFO sources of information report significantly more frequently than others. It also must be noted that the DFO info, although only reported every 12 hours, contains position information at 10 minute or better intervals.

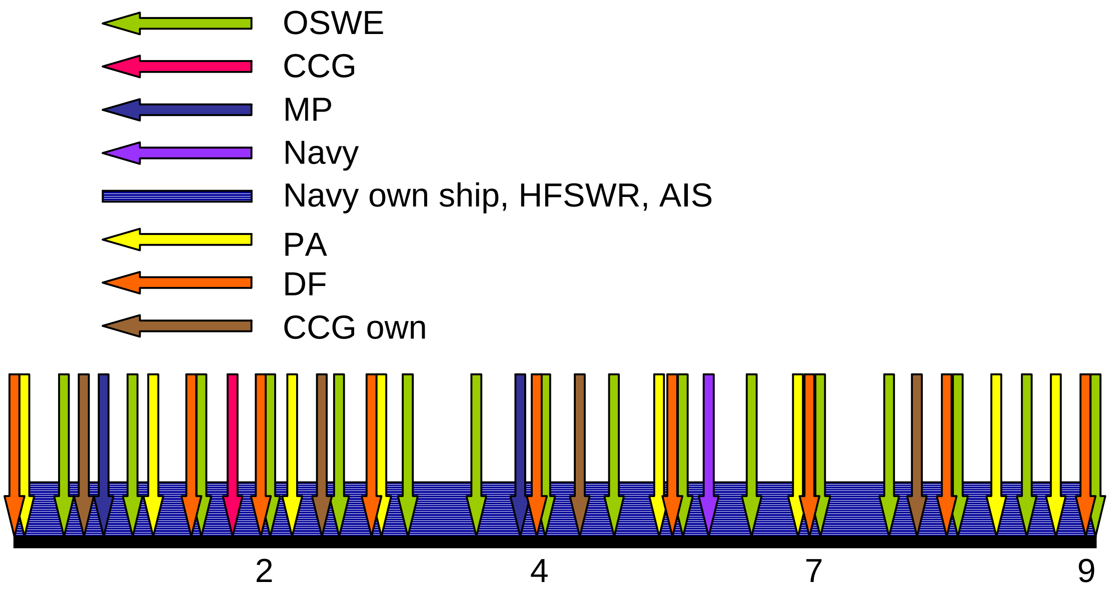

Figure 3. *Vessel detection frequency*

4.3.5 Summary

Table 4 shows a qualitative analysis of the criteria outlined above. The assessment of each criterion is based on “High/Med/Low” ratings (or Unknown). For some sources listed there is missing information that could not be obtained for this analysis.

For the purpose of creating a valid scenario for use in the RTB, the criteria are not of equal importance. It is more important that the source of information capture the greatest percentage of the maritime traffic (frequency/number of vessels) and that the information is timely, than that the position is accurate or that there is extensive information.

From this table, it can be seen that the sensors which have already been included were good choices – they all capture a large percentage of the total maritime traffic with a high degree of timeliness. To continue with the modeling effort, there are some data sources that should take priority, in particular:

AIS should be attached to all vessel models that should have it, and all AIS receivers should be modeled. AIS captures a large number of the vessels with easy-to-model reporting. It is also anticipated that these transponders will be increasingly required in the future, and therefore could be expected to capture a greater percentage of the maritime traffic.

The PAL flights should be modeled, as this gives a fairly significant capture percentage with good timeliness and accuracy. In addition, the model used for PAL would be easily modified to represent either an MPA or UAV.

Other data sources could be modeled as effort is available, and it would be valuable to answer some of the remaining unknowns about new information sources. The ability to track maritime traffic by satellite, for example, could ensure that the location data of all vessels in an area of interest is completely accurate and timely, although another means of providing specific identification would be required.

Table 4. *Qualitative analysis of the entities' characteristics*

VESSELS	***Frequency***	***# of Vessels***	***Accuracy***	***Timelines***	***Amt of Info***	***Modeling Difficulty***
OSWEX	Med	High	Med	High	High	Low
CCG INNAV	Very Low	High[1]	Med	High	High	Low
MPA	Low	Low		High	Med	High
CF Navy own ship	High	Low	High	High	High	Low
Navy reports	Med	Low	High	Low	High	Med
PAL	Med	Med	High	High	Med	Med
HFSWR	High	High	Med	High	Low	Med
AIS	High	Med	High	High	High	Low
ELINT	UK	Low	Low	UK	UK	High
DFO	High	Low	Med	Low	UK	Low
CCG own ship	Low	Low	High	Med	High	Low
EO Satellites	UK	High	High	High	Low	Low

1 However, a ship bound for port may not be in the Area of Interest at the time they send the message.

UAV	UK[2]	Low	High	High	Med	Med
ONI	UK	Low	Med	Low-Med	UK	Low
TC A/C	UK	Low	High	Med	Med	Med
ECAREG	UK	UK	UK	UK	UK	Low

4.4 Integration of Live Data Sources

The integration of live data into the RTB simulation was mentioned as a possible need in the current task. This was never subsequently investigated due to the time shortage; however, the following paragraphs provide some high-level considerations for the potential integration of live data sources. If it is later determined that live sources are to be integrated, the feasibility, cost, and effort required for the particular data source(s) would have to be determined.

4.4.1 Integration of Live Entities

In the RTB there are three different simulated entity types: sensors, sensor platforms, and targets, where “target” refers to the commercial, fishing, and other vessels that make up maritime traffic in an area of interest. To create the Recognized Maritime Picture, there must be a realistic representation of the number and type of targets, and of the number, type, and capabilities of the sensors and sensor platforms. Any one or all of the three entity types could be real vessels or sensors in the relevant area of interest.

There are potential advantages to involving live entities, provided that the entity is integrated into the simulation with minimum data latency and suitable representation to and from the simulation of appropriate information. For the operator of a sensor or sensor platform (ship/aircraft), integration with the simulation could allow them to view and react to a RMP that would not otherwise exist, with specific scenarios to test their response or other capabilities. For the RTB and UAV control station, live integration could allow interaction with humans to perform necessary tasks. Integration of live sensors could allow accurate sensor results without considerations of too-high or too-low simulation fidelity. Integration could allow direct comparison of the performance of all live and virtual entities, and could allow participation by virtual operators in Ottawa with future large-scale live exercises.

There are very significant issues, however, with attempting to integrate live sources over long distances, as would be the case with the RTB in Ottawa and the live entities off the east coast. An issue that would have to be solved before any others could be

2 If not HIL simulations, could represent any frequency felt to be realistic in a future context.

considered is that of communication. It would be necessary to have information passed between airborne and shipborne live entities and the RTB with latency relative to the frequency of expected update of the entity information. For example, all live sensor platforms and targets would have to report their position. This has been done in large live/virtual exercises in the US (Synthetic Theatre of War exercises, for example), so it is certainly possible at a price.

A second important issue is ensuring the realism of interaction at both ends of the long-distance link: if a live sensor platform “sees” a target, that target must then appear in the RMP generated in Ottawa. Trickier, a virtual target generated in the RTB must be able to be “acted on” by a sensor platform in a realistic manner, without the target actually being in the live location that it should be according to the RMP.

Any decision to integrate live data sources would need to be made considering the potential benefits and costs. A detailed analysis of the communications methods, requirements for data integration, realism issues, and the like must be performed.

5. Lessons Learned

There were difficulties encountered during the development of the synthetic environment. We believe that the following causes contributed significantly.

5.1 Development Environment

The development environment, i.e. the architecture and software of the previous ALIX configuration, and more specifically the UAV Research Test Bed, was not favourable for a smooth development. It was assumed that building from the current configuration would speed development; however this was not clearly the case. Upgrading the main SE software, STRIVE, to STRIVE 2.0 from STRIVE 1.8 was deemed to be too costly for the present project alone. Within the UAV RTB build from ALIX, upgrading a single component is difficult due to plug-ins and bridges being hard-coded and linked with the STRIVE build. As a result, it appears that upgrading to STRIVE 2.0 requires rewriting the code for the STANAG 4586 plug-in, the OTH-Gold plug-in, and re-integration of image generators and video streaming. The modified STRIVE toolset and expired licenses also caused delays.

We note also that the current system has two different configurations; the second, produced by CMC Electronics, was not familiar to the contractor's developers.

Existing documentation for the UAV RTB and the ALIX SE [14] is clearly insufficient. Much of the information was captured [RTB portal website reference], but insufficient for to capitalize on existing development as a starting place.

In short, the current development environment reflects a lack of knowledge management and process infrastructure. This is being rectified with the introduction of formal processes for development and documentation that will lead to a more efficient development environment; among other we can cite: Process Benchmarking and Business Process Improvement (BPI) [9].

5.1.1 Knowledge Management

According to Ocean Literacy "Knowledge refers to what one knows and understands. Knowledge is sometimes categorized as unstructured, structured, explicit or tacit. What we know we know is explicit knowledge. Knowledge that is unstructured and understood, but not clearly expressed is implicit knowledge. If the knowledge is organized and easy to share then it is called structured knowledge. To convert implicit knowledge into explicit knowledge, it must be extracted and formatted." [13]

Good knowledge management within an organization facilitates communication across projects, increasing information sharing and utilizing process documentation. This information sharing promotes organizational unity and allows the organization to

function efficiently. The truth is that organizational knowledge and best practices are found in only one place within the organization, i.e. the employee's mind. A mind set that "knowledge is power" for the employee leads to implicit, undocumented knowledge that is at risk upon the loss of individual employees. On the other hand, explicit knowledge can be shared throughout the organization. It consists of the documented experiences of those who have performed a given task.

According to Burke & Howard, the traditional "Progress" is first data, then information, then knowledge and finally, wisdom [7]. Data alone has little value unless it is properly structured or organized. Once appropriately organized, data becomes more useful as information. Information leads to knowledge and it has many definitions. Wisdom comes from the ability to synthesize various streams of knowledge, enough to be able to make informed judgments about various ideas and propositions that may lie outside direct areas of expertise.

Consider this observation made by Neil Fleming [6] as a basis for thought relating to the following diagram.

- A collection of data is not information.
- A collection of information is not knowledge.
- A collection of knowledge is not wisdom.
- A collection of wisdom is not truth.

The idea is that information, knowledge, and wisdom are more than simply collections. Rather, the whole represents more than the sum of its parts and has a synergy of its own, as shown in Figure 4.

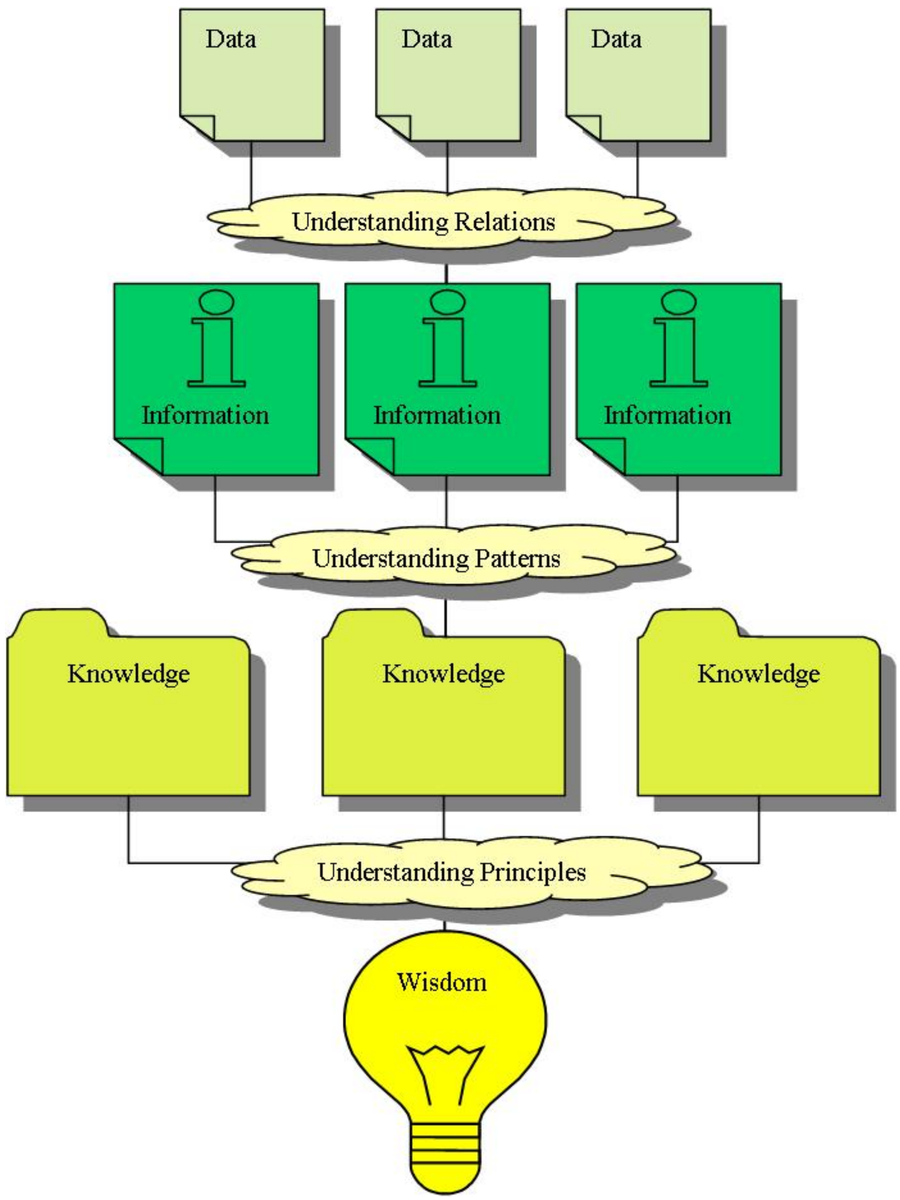

Figure 4. *The Progress*

Knowledge management is a systematic approach to facilitate the flow of data, information, and knowledge to the right people at the right time so they can act more efficiently and effectively. Knowledge management requires an organizational effort to build, operate, maintain, and proliferate a knowledge-sharing environment. To create value and build a competitive edge, the organization needs to be able to retrieve and understand the structured and unstructured data, convert data into useful information, and share the knowledge.

5.1.2 Process Infrastructure

A capability the FFSE is lacking for the efficient development of a synthetic environment is the process infrastructure. While it is true that much of the development is done by contractors, the crown must be responsible for maintaining deliverable code and systems, and putting the components together as pieces of a puzzle. Having a robust process development will help prevent projects that are late, over budget, or do not deliver key functionality.

As projects continue to increase in size and importance, these problems become magnified. They can be overcome through a focused and sustained effort at building a process infrastructure of effective software engineering and management practices.

To build such process infrastructure, FFSE must assess the ability to perform the software process successfully. FFSE also needs guidance to improve the process capability. FFSE need ways to evaluate more effectively the capability to perform successfully on system engineering contracts.

The Capability Maturity Model (CMM), developed by the Software Engineering Institute (SEI) of Carnegie Mellon University, delineates the characteristics of a mature, capable software process, and can adequately satisfy this need. The model describes, in terms of maturity levels, the progression from an immature, unrepeatable software process to a mature, well-managed software process. CMM is sponsored and used by the DoD and the National Defense Industrial Association (NDIA). [12]

Therefore, it is recommended that FFSE adopt CMM, by applying the good practices recommended by the model and which are grouped in the following 5 levels of maturity:

- Initial: the processes are ad hoc and chaotic. The factors of success of the projects are not identified; thus the success cannot be repeated.

- Repeatable: projects are controlled individually.

- Defined: the processes of piloting the projects are set up at the organizational level. The processes are well characterized and understood, and are described in standards, procedures, tools, and methods.

- Managed: the success of the projects is quantified. The causes of variation can be analyzed.

- Optimized: the step of optimization is continuous. Maturity level 5 focuses on continually improving process performance through both incremental and innovative technological improvements. [12]

It could be argued that FFSE is currently at the level of *Repeatable* execution processes, because identical data sets can be produced through re-use of previous experimental set-ups. The authors highly recommend progressing within the maturity

categorizations, not simply by awaiting maturity of the organization and surrounding simulation partners, but by actively initiating, employing and documenting the processes surrounding an experiment in FFSE.

5.2 Team Roles for the SE Development

There was some confusion in the roles of the FFSE and RAST staff. For this project and likely for future projects, the FFSE section has the role of project sponsor and is responsible for the SE across multiple projects. The RAST section was the stakeholder; in the future the CF may take this role directly as the client. However, these roles emerged during this project and were not clearly defined at the outset or during the whole lifecycle of the project.

The contractor, Greenley & Associates Inc., [8] defines itself as a consulting service provider that offers clients expertise in the core service areas of modeling and simulation, project management human factors, business analysis and usability, and emergency management.

In a multi project environment, like that employed by Greenley & Associates, where personnel are shared across a number of different projects, the list of tasks for both individual employees and projects can be lengthy. Such an environment, typically, generates many priorities for project resources and managers alike and can make focus difficult to achieve. In such situations, dedicating resources to projects might waste them by making them unavailable to support other more important projects.

5.3 Project Management

The project manager is the catalyst for the good progress of the project and the detector of potential problems which would cause slippage in the project schedule.

The project manager is the link between the client and the contractor team and this link was lacking in this project. Here, the situation was that a junior developer was required to manage the relationship and information flow with a sub-contractor (in this case, CAE Inc.), and communicate the situation to the stakeholder in the RAST section.

We believe that clear communication is necessary between all parties and it is the responsibility of the program manager to make the program understood and accepted by all.

It also appears that the difficulty of the task was underestimated by both the contractor and the FFSE section. This may be a result of an overestimate of the capacity of the tool i.e. CAE-STRIVE.

Risk mitigation should proactively target risk drivers. Structured effectively, a risk mitigation program should prevent loss and reduce the repercussion of losses that do

occur. During the planning stage, the contribution of a senior software engineer was envisioned, scoped and budgeted. During the execution of the entire project, no senior software engineer was involved. The bulk of the work was made the responsibility of a junior Software Engineer We assume that this was due to stretching of resources within the contractor’s organization which can at times be unavoidable due to instability or volatility in the industry. But what must be highlight here is that nothing was done, from the program management point of view, to mitigate this loss.

6. Conclusions and Future Work

The benefits of an SE approach as a component of programs for experimentation and capability development are clear in terms of scalability, cost effectiveness and practicality. SEs also offer the opportunities for operators to gain experience in operations, and training before new equipment is fully available, or for large numbers of staff for whom sufficient equipment could not be made available. This is in line with the DRDC thrust description (see http://admmatapp.dnd.ca/cosmat/dmasp/downloads/ModellingSimulation/)

The present task showed that even with low fidelity models, an SE we can be produced that is suitable for evaluating the challenge experienced by operations teams to fuse all the data for Recognized Maritime Picture (RMP) generation.

The range of missions, for maritime ISR in particular, that can be executed in a synthetic environment is growing more expansive and synthetic environment are becoming increasingly important for analysis of C2/C4ISR systems. An SE Mission Rehearsal and Training documents the shortcomings with systems as well as the requirements of the future systems, and addresses the ability to integrate different models with regard to forces, infrastructures, tactics, techniques and procedures.

The present task also revealed several lacunas that are gathered in the lessons learned section. Some of these can be significant, especially as the FFSE section grows in terms of variety of the projects it tackles. The two most critical issues are the lack of knowledge management and the lack of process infrastructure.

To offer better support for future Maritime Traffic Simulation trials, future development must include:

- The continued development of entity models and sensor models to complete the maritime environment and the continued improvement to the current set of models. Along with the resolution of the fidelity issues.

- The exploration of decoupling the developed entity and sensor models from the simulation toolset by designing these models as standalone federates.

- The investigation of other simulation toolsets: some difficulty was found with the current simulation tool, i.e. CAE-STRIVE [12], and to maintain a vibrant, competitive industry of providers, as well as ensure a suitable selection of tools, other tools must be investigated. This is being pursued in a current project within the FFSE section on SE tool analysis

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Appendix A – Maritime Traffic Fishing Dataset

FFSE 106 FISH Data Final.xls

HITT ID	Class	Name	Type	Category	AAI	Flag	SCONUM	UID	INTL Radio Call Sign	Date-Time	Lat	Long	Speed	Course
54	UNEQUATED	MADELEINE	FISH	MER	AAI	CA	N19022	CMN462457444	VC9391	8/29/12:45:00	44.176795	-49.516868	2.9	069.3T
77	UNEQUATED	ONTIKA	FISH	MER	AAI	EN	N41504	CMN461226957	ESKO	8/29/12:00:00	44.541808	-53.324044	4.1	201.4T
76	UNEQUATED	TAURUS	FISH	MER	AAI	EN	M64155	CMN461238016	ESPO	8/29/12:00:00	44.174177	-52.936051	3.5	053.2T
94	UNEQUATED	MADRUS	FISH	MER	AAI	EN	M04464	CMN461237545	ESGO	8/29/06:25:00	48.890677	-52.360871	3.3	130.2T
144	UNEQUATED	ELDBORG	FISH	MER	AAI	EN	N25238	CMN461237546	ESPY	8/29/06:28:00	44.156102	-52.110117	4	067.9T
152	UNEQUATED	ANDVARI	FISH	MER	AAI	EN		CMN461237547	ESPD	8/29/07:02:00	50.086307	-52.085428	3.6	000.4T
123	UNEQUATED	HOGIFOSSUR	FISH	MER	AAI	FO	M64053	CMN461238147	OW2348	8/29/03:22:00	47.032816	-51.66255	5.1	000.4T
130	UNEQUATED	SOLBURG	FISH	MER	AAI	FO	M04138	CMN461224802	TFFT	8/29/03:54:00	43.23956	-51.488123	3.8	296.4T
30	UNEQUATED	ENNIBERG	FISH	MER	AAI	FO	M10606	CMN461234102	XPXL	8/29/12:34:00	43.987191	-50.75861	2.1	053T
13	UNEQUATED	CSO MARIANOS	FISH	MER	AAI	BF	M35812	CMN462456365	C6LQ3	8/29/12:45:00	44.394803	-49.879452	3.7	051.3T
132	UNEQUATED	POLAR SIGLIR	FISH	MER	AAI	GL	M43227	CMN461253040	OZPL	8/29/04:44:00	49.642902	-51.43393	3.8	193.9T
22	UNEQUATED	ZUIHO MARO NO88	FISH	MER	AAI	JA	N50397	CMN461237545	JMSA	8/29/12:00:00	49.211226	-53.35956	2.3	112.1T
7	UNEQUATED	TENOR	FISH	MER	AAI	NO	M07865	CMN461242703	LALU	8/29/07:51:00	46.905435	-52.07594	3.9	000.4T
165	UNEQUATED	SAEVIKING	FISH	MER	AAI	NO	M08263	CMN461237999	LLNF	8/29/07:32:00	43.807822	-52.017246	2.1	048.1T
17	UNEQUATED	ARCTICSWAN	FISH	MER	AAI	NO	M06213	CMN461237549	LMAC	8/29/05:43:00	50.287676	-52.005798	3.1	039.2T
57	UNEQUATED	ATLANTICSTAR	FISH	MER	AAI	NO		CMN462456680	LMBG	8/29/04:23:00	44.135566	-51.849662	4.1	112.1T
65	UNEQUATED	VESTTIND	FISH	MER	AAI	NO		CMN461237551	LMCX	8/29/07:48:00	44.961518	-51.812085	2.2	000.4T
137	UNEQUATED	LOUIS M LAUZIER	FISH	MER	AAI	CA	M06213	CMN461237549	VOXS	8/29/12:45:00	45.719783	-49.921667	3.2	000.4T
84	UNEQUATED	LEONID NOVOSPASSKIY	FISH	MER	AAI	RS	M58083	CMN461237567	UHLW	8/29/07:37:00	49.539009	-51.204421	4.4	000.4T
18	UNEQUATED	GEMENY	FISH	MER	AAI	RS		CMN461237572	UIXH	8/29/02:54:00	44.36317	-50.969523	2.1	000.4T
140	UNEQUATED	AROUND THE CLOCK	FISH	MER	AAI	RS	M58083	CMN461237567	UHLW	8/29/12:45:00	47.2345	-49.3554	3.6	049.5T
108	UNEQUATED	PATRICIA SOTELO	FISH	MER	AAI	SP	N71901	CMN461237531	EAVX	8/29/12:00:00	45.501948	-49.3554	5.1	040.2T
162	UNEQUATED	PLAYA DE ARNELES	FISH	MER	AAI	SP		CMN461237532	EGWJ	8/29/12:00:00	47.177267	-50.622242	3.8	296.4T
150	UNEQUATED	EIRADO DO COSTAL	FISH	MER	AAI	SP		CMN462456220	EGKW	8/29/12:00:00	44.498575	-50.591212	2.1	296.4T
36	UNEQUATED	PLAYA DE MENDUINA	FISH	MER	AAI	SP		CMN462455781	EEKN	8/29/12:00:00	43.324546	-50.576372	3.7	314.9T
80	UNEQUATED	MANUEL ANGEL NORES	FISH	MER	AAI	SP	M57130	CMN46123533	EAMC	8/29/12:00:00	47.002809	-50.489941	3.8	067.9T
43	UNEQUATED	MORADINA	FISH	MER	AAI	SP	N30927	CMN461237534	EDQR	8/29/12:00:00	46.757459	-50.190701	2.3	149.3T
79	UNEQUATED	SANTA MARINA	FISH	MER	AAI	SP	N46093	CMN461237536	EEMX	8/29/12:00:00	45.090233	-49.991839	3.9	055.3T
68	UNEQUATED	CODESIDE	FISH	MER	AAI	SP	N32365	CMN461237543	EHUZ	8/29/12:00:00	49.922356	-49.935683	2.1	000.4T
13	UNEQUATED	BUSSOL	FISH	MER	-	RS	M33672	CMN462456773	UCTZ	8/29/12:00:00	44.2342	-49.525	2.1	296.4T
140	UNEQUATED	ATLANTIC PEACE	FISH	MER	-	GM	M05907	CMN461237948	DEOT	8/29/12:00:00	47.393092	-49.685502	3.6	000.4T
54	UNEQUATED	NEWFOUNDLAND OTTER	FISH	MER	-	CA	M12179	CMN461236828	CFD365	8/29/12:00:00	44.1037	-49.31	5.1	000.4T
135	UNEQUATED	GERDA MARIA	FISH	MER	-	GM	M11321	CMN461246840	DFLM	8/29/12:00:00	48.085568	-49.456884	3.8	000.4T
61	UNEQUATED	STRAIT FALCON	FISH	MER	-	CA	M54102	CMN461249067	HP9417	8/29/12:00:00	46.454511	-49.059975	2.1	060.2T
2	UNEQUATED	PESCABERBES	FISH	MER	-	SP	M06935	CMN461226956	EHXX	8/29/12:00:00	46.203914	-48.840597	3.7	149.3T
139	UNEQUATED	COVA	FISH	MER	-	SP	M51966	CMN461237537	EGBP	8/29/12:00:00	44.666348	-48.422274	2.3	000.4T
151	UNEQUATED	OZERNITSA	FISH	MER	-	RS	M57854	CMN461252952	UIDS	8/29/12:00:00	45.871371	-48.121457	3.9	296.4T

Appendix B – Maritime Traffic Merchant Dataset

FFSE 106 MER Data Final.xls

HITT ID	Class	Name	Type	Category	OSWEX	AIS	Flag	SCONUM	UID	INTL Radio Call Sign	Date-Time	Lat	Long	Speed	RMKS
4	UNEQUATED	FERBEC	BLK	MER		AIS	PM	M54102	CMN461249067	HP9417	8/29/12:48:00	41.907	-54.463	18.84	
											8/29/18:21:00	42.736	-52.386	20.23	
											8/30/00:47:00	43.131	-49.705	18.41	
											8/30/23:19:00	44.571	-40.222	17.63	
22	UNEQUATED	VANCOUVERBORG	BLK	MER		AIS	CA	M58923	CMN462456396	VOCQ	8/29/12:49:00	43.104	-49.612	19.79	
											8/29/18:19:00	43.592	-46.950	23.35	
											8/29/23:44:00	44.233	-44.332	22.48	
											8/30/06:38:00	44.888	-40.971	21.79	
											8/30/08:44:00	45.312	-40.095	20.23	
27	UNEQUATED	SAGA TUCANO	BLK	MER		AIS	BB	N62619	CMN461251242	8PNO	8/29/12:33:00	45.914	-54.105	21.89	
											8/29/18:01:00	45.764	-51.263	23.51	
											8/29/23:24:00	45.429	-48.463	22.93	
											8/30/06:11:00	45.696	-44.912	21.61	
											8/30/12:35:00	45.413	-41.715	23.66	
											8/30/15:12:00	45.390	-40.290	23.39	
28	UNEQUATED	IRENES SYNTHESIS	BLK	MER		AIS	CY	M43069	CMN462454112	C6PG6	8/29/12:19:00	43.813	-53.470	20.42	
											8/29/18:39:00	45.659	-52.421	19.60	
											8/29/23:59:00	47.304	-51.613	18.32	DESTINATION:ANTWERP
											8/30/06:11:00	48.668	-49.458	18.33	MMSI#:21081800
											8/30/12:29:00	49.921	-47.064	20.57	
											8/30/23:37:00	51.789	-41.921	18.62	
1	UNEQUATED	MOBILE	TUG	MER		AIS	US		CMN461237591	VCRG	8/29/12:47:00	48.156	-49.079	13.55	
											8/29/18:53:00	49.568	-48.330	12.51	
											8/30/04:10:00	50.608	-45.292	13.34	
											8/30/12:55:00	51.439	-42.401	15.86	
2	UNEQUATED	ALGOMARINE	BLK	MER		AIS	CA	N16267	ROC462608453	VGJV	8/29/12:20:00	49.284	-48.091	16.18	
											8/29/18:00:00	49.958	-46.014	17.45	
											8/30/02:55:00	51.119	-42.534	17.20	
											8/30/10:33:00	52.437	-40.103	14.96	
10	CCG	COURTENAY BAY		NAV	OSWEX		CA	N67033	CMN461251037	A8BI4	8/29/12:24:00	43.096	-54.302	13.94	
											8/29/18:23:00	44.226	-55.656	15.98	
											8/29/23:24:00	45.339	-56.452	17.21	
											8/30/06:49:00	46.785	-58.355	14.14	
31	UNEQUATED	CEDARGLEN	BLK	MER		AIS	CA	M57854	CMN461252952	VCLN	8/29/12:01:00	48.035	-43.736	13.01	
											8/29/19:05:00	47.458	-45.795	13.94	
											8/30/01:09:00	46.676	-47.230	10.66	
											8/30/11:57:00	45.585	-49.657	12.65	
											8/30/20:53:00	44.742	-51.840	12.09	
											8/30/23:32:00	44.509	-52.464	12.88	
37	UNEQUATED	GRIFFON	WAGL	MER	OSWEX		CA	M33323	CMN461237133	CGDS	8/29/12:36:00	42.478	-49.392	12.80	
											8/29/23:04:00	44.431	-50.907	14.37	
											8/30/6:57:00	45.822	-52.322	12.26	
											8/30/16:17:00	46.312	-55.106	11.96	
											8/30/23:14:00	46.332	-57.277	11.34	
54	UNEQUATED	LEIF ERICSON	TMF	MER	OSWEX		CA	N52336	CMN461237617	VOCJ	8/29/12:07:00	46.090	-55.268	15.97	
											8/29/21:51:00	45.613	-51.380	15.80	
											8/30/12:36:00	43.031	-47.285	19.04	
											8/30/22:44:00	40.172	-46.147	15.40	
56	UNEQUATED	GREENWING	BLK	MER	-		CY		CMN461251062	P3GG9	8/29/12:17:00	46.206	-56.268	15.15	

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HITT ID	Class	Name	Type	Category	OSWEX	AIS	Flag	SCONUM	UID	INTL Radio Call Sign	Date-Time	Lat	Long	Speed	RMKS
											8/29/20:23:00	46.140	-53.376	16.39	
											8/30/8:53:00	45.048	-49.404	15.25	
											8/30/18:12:00	43.796	-46.785	14.18	
											8/30/23:35:00	43.086	-45.367	15.20	
58	UNEQUATED	IV 14	CGO	MER			CA	N18847	CMN460648133	VC6654	8/29/12:35:00	41.992	-54.364	18.44	
											8/29/18:57:00	42.269	-51.687	19.03	
											8/30/06:35:00	43.627	-46.935	18.07	
											8/30/18:11:00	44.931	-42.055	17.56	
											8/30/22:58:00	45.678	-40.199	19.21	
60	UNEQUATED	OOCL BELGUIM	TMCS	MER			HK		CMN461252914	VRVQP	8/29/12:51:00	41.407	-56.018	15.94	
											8/29/23:13:00	42.021	-52.788	16.28	
											8/30/17:01:00	43.638	-47.439	14.35	
											8/30/23:14:00	43.979	-45.407	14.09	
63	UNEQUATED	NIRINT ATLAS	CGO	MER			BF		CMN462455512	C6QX8	8/29/12:42:00	40.080	-56.180	13.81	
											8/29/18:11:00	40.527	-54.660	15.12	
											8/30/14:41:00	43.419	-49.899	14.69	
											8/30/23:40:00	43.021	-47.217	12.19	
86	UNEQUATED	CSO MARIANOS	TMK	MER			BF	M06032	CMN461251039	C6LQ3	8/29/13:06:00	42.087	-56.079	16.55	
											8/29/22:06:00	42.370	-53.078	14.15	DESTINATION: STJOHNS
											8/30/14:10:00	43.104	-47.853	16.80	MMSI#:308389000 NAVIGATIONAL
											8/30/23:58:00	44.396	-44.885	15.71	STATUS: UNDERWAY
90	UNEQUATED	BIN HAI 512	AGE	MER		AIS	PM	M54102	CMN461249067	HP9417	8/29/12:17:00	44.084	-43.597	20.68	
											8/29/21:12:00	43.348	-47.572	18.63	
											8/30/15:06:00	41.718	-55.217	21.59	
											8/30/23:51:00	41.949	-59.231	22.11	
100	UNEQUATED	ATLANTIC CONCERT	TME	MER		AIS	SW	M62714	CMN461250831	VGCY	8/29/12:45:00	40.676	-51.889	16.64	
											8/29/20:43:00	42.634	-52.399	16.40	DESTINATION:HALIFAXCA
											8/30/11:02:00	45.758	-54.551	14.47	MMSI#:265137300 NAVIGATIONAL
											8/30/23:24:00	46.899	-58.504	16.64	STATUS:UNDERWAY USING ENGINE
112	UNEQUATED	HOLIDAY ISLAND	TMF	MER			CA	M35187	CMN461246976	VGCY	8/29/22:00:00	43.251	-40.030	20.84	
											8/30/8:21:00	43.494	-44.498	19.37	
											8/30/23:59:00	42.372	-50.587	20.67	
											8/31/06:40:00	42.255	-53.945	18.63	
121	UNEQUATED	MONTREALAIS	BLK	MER			CA	N06239	CMN462455212	VDWC	8/30/02:00:00	41.249	-59.676	20.67	
											8/30/12:47:00	41.892	-54.748	22.35	
											8/30/22:12:00	41.951	-50.404	19.96	
											8/31/09:10:00	43.805	-45.975	19.92	
137	UNEQUATED	EARL W OGLEBAY	BLK	MER			US	N25365	CMN462455324	WZE7718	8/30/11:00:00	41.644	-59.730	23.62	
											8/30/22:27:00	42.305	-54.108	21.48	
											8/31/05:15:00	42.542	-50.728	21.60	
											8/31/11:57:00	43.343	-47.515	22.69	
15	UNEQUATED	SAFMARINE GONUBIE	TMCS	MER			GM	M43069	CMN462454112	DGVB	8/29/12:27:00	42.083	-54.724	17.16	
											8/29/18:49:00	42.367	-52.392	17.41	
											8/30/02:46:00	42.678	-49.362	16.96	
											8/30/12:08:00	43.485	-46.116	15.59	
											8/30/16:41:00	43.855	-44.462	15.62	
16	UNEQUATED	JUMBO VISION	TMB	MER			NL	M47410	CMN460649452	PBBG	8/29/12:50:00	45.862	-55.294	17.08	
											8/29/20:01:00	46.453	-52.527	17.98	

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HITT ID	Class	Name	Type	Category	OSWEX	AIS	Flag	SCONUM	UID	INTL Radio Call Sign	Date-Time	Lat	Long	Speed	RMKS
											8/30/18:47:00	46.894	-43.612	18.19	
											8/30/23:30:00	47.306	-41.872	15.43	
17	UNEQUATED	CORONA	CGO	MER			CY	M12179	CMN461236828	P3YV7	8/29/12:10:00	40.924	-56.285	13.24	
											8/30/20:43:00	40.753	-53.653	16.72	
											8/30/12:40:00	42.873	-49.275	15.12	
											8/30/23:58:00	43.800	-45.762	16.46	
18	UNEQUATED	CAPETAN MICHALIS	BLK	MER			GR	M63522	CMN461237961	SZGE	8/29/12:25:00	46.154	-55.035	15.95	
											8/29/20:46:00	45.896	-51.811	16.01	
											8/30/10:46:00	46.719	-46.214	18.34	
											8/30-23:09:00	48.137	-41.476	18.37	
19	UNEQUATED	OSTANKINO	TMO	MER			CY	M62714	CMN461250831	P3OF4	8/29/12:51:00	46.115	-55.552	16.82	
											8/29/20:39:00	46.378	-52.679	14.92	
											8/30/12:18:00	48.708	-48.045	15.68	
											8/30/23:22:00	50.527	-44.897	13.73	
22	UNEQUATED	TRANS ST LAURENT	TME	MER			CA	M44134	CMN461245760	CYLY	8/29/12:11:00	42.304	-55.210	16.69	
											8/29/20:00:00	42.210	-52.167	16.54	
											8/30/10:12:00	43.441	-47.094	18.29	
											8/30/23:13:00	44.813	-42.230	16.74	
23	UNEQUATED	SCOTIA PRINCE	TMF	MER			BF	M54102	CMN461249067	HP9417	8/29/12:23:00	41.993	-50.554	18.75	
											8/29/20:06:00	43.205	-48.033	18.39	
											8/30:11:21:00	43.682	-41.864	18.69	
											8/30:15:33:00	43.715	-40.133	17.30	
25	UNEQUATED	VANCOUVER SPIRIT	TMO	MER			BF	M62714	CMN461250831	C6LC39	8/29/14:19:00	41.938	-54.758	17.18	
											8/29/23:21:00	41.696	-51.766	16.82	
											8/30/14:55:00	43.317	-46.918	16.84	
											8/30/23:37:00	44.052	-44.058	15.67	
29	UNEQUATED	MAERSK ROCHESTER	TMO	MER			UK		CMN462455426	MZIL8	8/29/12:35:00	46.778	-52.756	13.94	
											8/29/19:24:00	45.734	-54.774	17.13	
											8/29/10:15:00	44.847	-59.939	15.53	
31	UNEQUATED	MALMNES	BLK	MER			PM	M54102	CMN461249067	LAQX4	8/29/17:17:00	44.333	-48.968	15.08	
											8/29/10:22:00	48.260	-46.700	14.25	
											8/30/19:12:00	50.360	-45.479	16.11	
											8/31/01:23:00	51.487	-43.935	13.72	
33	UNEQUATED	CAPT HENRY JACKMAN	BLK	MER			CA		CMN462454047	VCTV	8/29/12:10:00	43.621	-44.301	14.91	
											8/29/18:38:00	43.722	-46.722	16.62	
											8/30/03:52:00	42.809	-49.906	17.02	
											8/30/23:39:00	41.745	-57.015	16.82	
36	UNEQUATED	JOSEPH AND CLARA SMALLWOOD	TMF	MER			CA			VOLV	8/29/14:59:00	41.695	-54.120	17.92	
											8/30/01:00:00	42.113	-50.470	18.52	
											8/30/09:47:00	43.164	-47.401	18.72	
											8/30/23:57:00	43.425	-42.059	17.68	
37	UNEQUATED	DEEPWATER PATHFINDER	TMGS	MER			PA			HP9216	8/29/12:57:00	43.384	-41.487	16.76	
											8/29/23:06:00	45.757	-42.572	16.96	
											8/30/15:31:00	48.539	-46.769	15.91	
											8/31/00:50:00	50.237	-49.021	13.25	
40	UNEQUATED	CANMAR BRAVERY	CGO	MER			BD	M47241	CMN462458262	ZCBS2	8/29/12:33:00	41.911	-55.744	13.60	
											8/29/22:51:00	42.384	-52.431	13.02	
											8/30/18:44:00	43.730	-46.369	12.57	
											8/31/00:51:00	44.412	-44.505	15.09	

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HITT ID	Class	Name	Type	Category	OSWEX	AIS	Flag	SCONUM	UID	INTL Radio Call Sign	Date-Time	Lat	Long	Speed	RMKS
43	UNEQUATED	TRANSIT	BLK	MER	OSWEX		HK	N53415	CMN462455303	VRZB4	8/29/12:22:00	45.447	-50.948	14.19	
											8/30/00:26:00	46.137	-55.038	17.12	
											8/30/13:58:00	47.027	-59.962	15.11	
45	UNEQUATED	LEONARDO LEMBO	BLK	MER	OSWEX		IT	M12179	M3A461137363	IBAL	8/29/13:30:00	41.905	-55.329	15.27	
											8/30/23:50:00	41.967	-51.650	16.30	
											8/30/19:14:00	43.483	-45.228	16.29	
											8/30/23:09:00	43.683	-43.871	16.83	
47	UNEQUATED	LOMUR 2	CGO	MER	OSWEX		BB	M60078	CMN461229472	LATU4	8/29/12:25:00	45.087	-53.270	15.67	
											8/30/23:52:00	47.873	-51.119	15.66	
											8/30/18:07:00	50.559	-44.652	18.36	
											8/31/01:37:00	51.581	-41.911	16.43	
49	UNEQUATED	ARCTIC SWAN	TMOS	MER	OSWEX		PM	M64722	M3A461147035	3EWG8	8/29/12:15:00	42.144	-55.092	14.96	
											8/30/00:06:00	42.435	-50.767	14.75	
											8/30/18:24:00	43.555	-44.134	15.32	
											8/30/23:57:00	43.181	-42.139	17.57	
56	UNEQUATED	PRIDE OF THE SOUTH	CGO	MER		AIS	PA		CMN462453989	3FYZ7	8/29/12:30:00	46.258	-55.735	18.29	
											8/29/23:58:00	46.451	-51.039	16.84	
											8/30/18:57:00	46.491	-43.429	18.85	
											8/30:23:18:00	46.937	-41.725	16.53	
57	UNEQUATED	ALBATROS	CGO	MER		AIS	PA	N29089	CMN462456755	3FPN3	8/29/12:25:00	46.864	-43.129	15.44	
											8/29/23:47:00	47.947	-47.229	14.24	
											8/30/17:21:00	46.506	-53.031	14.52	
											8/30/23:29:00	45.922	-55.024	14.21	
58	UNEQUATED	OCEAN ECHO II	YFB	MER		AIS	CA	M27831	CMN460566310	VCP004	8/29/12:21:00	40.991	-53.585	15.32	
											8/29/23:47:00	42.768	-50.777	13.46	
											8/30/18:24:00	43.105	-44.706	12.68	
											8/31/01:03:00	42.902	-42.672	16.43	
62	UNEQUATED	ATLANTIC PRIDE	BLK	MER		AIS	LI	N14061	CMN462455344	D5G5	8/29/12:01:01	44.553	-59.687	16.38	
											8/29/20:53:00	45.847	-56.652	15.60	
											8/30/14:16:00	46.873	-49.973	17.91	
											8/30/23:04:00	46.545	-46.384	15.06	
65	UNEQUATED	ALGOSTEEL	BLK	MER		AIS	CA	M54102	CMN461249067	VDJB	8/29/15:00:00	43.119	-40.105	15.06	
											8/29/23:37:00	43.594	-43.137	16.72	
											8/30:18:00:00	42.817	-49.265	17.08	
											8/30/23:32:00	42.030	-50.993	16.52	
67	UNEQUATED	SAFMARINE CONGO	CGO	MER		AIS	CY	N01607	CMN462456741	P3FY9	8/29/17:00:00	42.692	-40.224	16.75	
											8/29/23:17:00	42.664	-42.604	15.78	
											8/30/18:49:00	42.916	-49.968	15.49	
											8/30/23:26:00	42.254	-51.410	17.35	
69	UNEQUATED	CORONA ACE	BLK	MER			PM	M54102	CMN461249067	3FPP4	8/29/20:00:00	42.329	-40.182	17.32	
											8/30/05:29:00	42.239	-43.891	15.51	
											8/30/18:51:00	43.315	-48.765	18.08	
											8/30/23:10:00	43.157	-50.462	17.57	
85	UNEQUATED	ALGOLAKE	BLK	MER			CA	M44134	CMN461245760	VCPX	8/30/18:00:00	45.208	-59.754	15.58	
											8/30/23:06:00	45.716	-58.126	15.65	

Appendix C – Maritime Traffic Other Dataset

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HITT ID	Class	Name	Type	Category	OSWEX	AIS	Flag	SCONUM	UID	Radio Call	Date-Time	Lat	Long	Speed
38	UNEQUATED	AMUNDSEN	AGB	NAV	OSWEX		CA	N54388	CMN461237598	CGDT	8/29/15:00:00	47.073	-49.471	8.00
											8/29/19:17:00	46.284	-48.271	13.00
											8/30/18:34:00	46.123	-68.170	14.00
											8/30/23:36:00	54.026	-54.160	10.00
39	UNEQUATED	MARTHA M. BLACK	AGB	NAV	OSWEX		CA	M07547	CMN46123656	CGCC	8/29/12:16:00	44.883	-52.071	12.90
											8/29/20:23:00	46.603	-52.476	13.93
											8/30/04:00:00	47.956	-50.958	13.02
											8/30/14:50:00	49.405	-47.874	13.71
											8/30/22:48:00	50.008	-45.324	14.46
78	UNEQUATED	ATHABASKAN	DDG	NAV	OSWEX	-	CA	A65088	CMN461237593	CYWM	8/29/12:49:00	41.930	-56.268	14.21
											8/29/22:41:00	42.426	-53.656	11.55
											8/30/15:29:00	43.068	-49.006	12.69
											8/30/23:17:00	43.386	-46.637	11.72
-	UNEQUATED	RV ENDEAVOR	AGE	MER	-	-	CA	M62714	CMN461250831	SKOZ	8/29/10:35:00	45.230	-51.107	10.00
											8/29/13:19:00	46.240	-46.450	12.00
											8/29/18:55:00	44.231	-52.226	12.00
-	UNEQUATED	CABOT SEA	AGE	MER	-	-	CA	N37044	CMN461237523	CFD8024	8/29/08:06:00	47.300	53.000	15.00
											8/30/18:06:00	-46.420	-56.341	14.00
-	UNEQUATED	CHARLES DARWIN	AGE	MER	-	-	CA	M54102	CMN461249067	GDLS	8/29/11:34:00	47.013	-50.261	15.00
											8/29/18:48:00	42.275	-82.451	12.00
											8/30/18:37:00	49.160	-70.460	11.00
83	UNEQUATED	BARBARA JEAN	YAC	MER	-	-	CJ		CMN462456792	ZCGA2	8/29/12:00:00	50.834295	-48.461585	3.80
137	UNEQUATED	PORT MECHINS	TMD	MER	-	-	PM	M54102	CMN462456792	VGWN	8/29/12:00:00	45.4313	-49.5627	4.40

Appendix D - STRIVE: SE Development Tool

Overview

In a nutshell, CAE STRIVE is a Commercial Off The Shelf (COTS) simulation development tool and mainly composed of two parts:

- STRIVE framework suite (AFX) is a Modeling and Simulation framework tool that gives software developers the ability to design complex interoperable systems.
- STRIVE CGF is a high fidelity full function synthetic, tactical environment and computer generated forces. It is a software product that simulates a real-time virtual battlefield for air, land, sea, and space applications.

The available version for FFSE, is STRIVE 1.8 beta version.

Customers can also add capabilities for specific needs such as radar, electro-optic, communications or weather.

Because STRIVE is a PC based and HLA compliant, systems and subsystems can be linked together as needed for a “plug-and-play” environment [1].

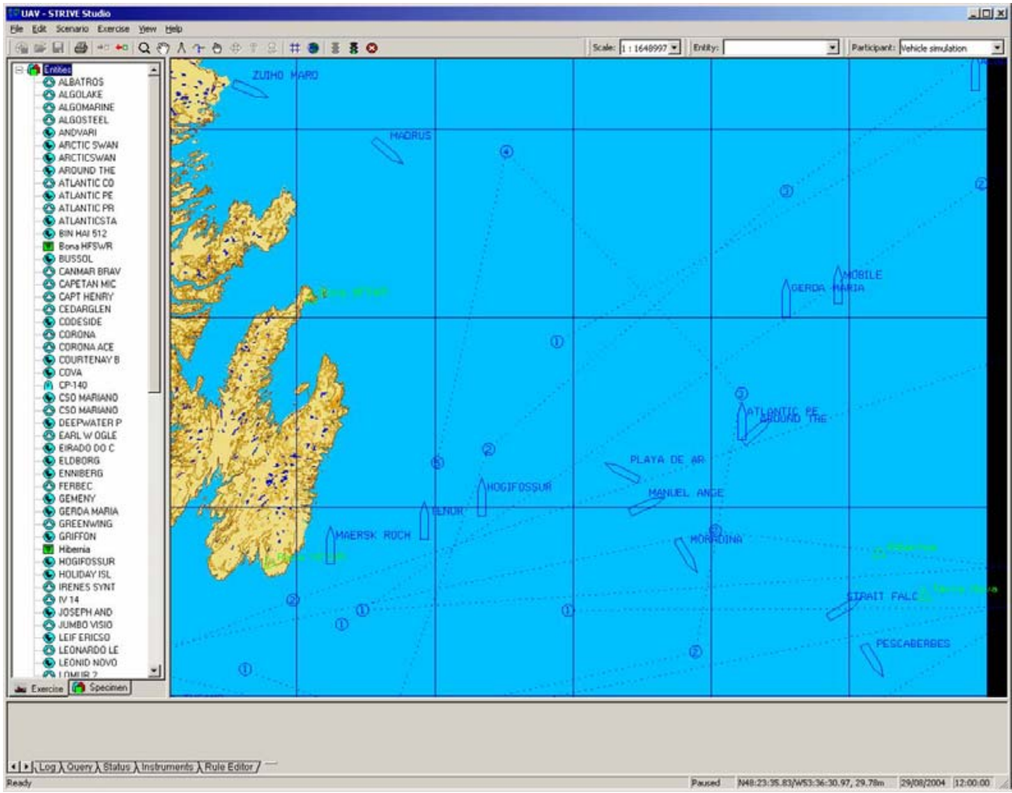

Figure 5. *STRIVE Screen Snapshot*

Usage of STRIVE in FFSE

Typically, a company or an organization will use STRIVE as a technological enabler to support all phases of a project's life, including research, analysis and acquisition. The FFSE section at DRDC Ottawa is a major user of STRIVE. Within FFSE, STRIVE is used for the evaluation of the potential of Unmanned Aerial Vehicles (UAV) and for the development of an expertise that would allow it to purchase UAVs. Another usage for STRIVE is the providing of a rehearsal and a set of complementary experiments in a synthetic environment for the Atlantic Littoral Intelligence Surveillance Reconnaissance Experiment (ALIX). The overall outcome for the rehearsal event was a demonstration of the potential for experimentation in synthetic environments. The experiment did not provide accurate predictions of quantitative measure compared to similar live experiments, because the entity models were not calibrated, (i.e. validated).

For more information, please see the DRDC technical note on this topic [12].

Appendix E – Installation Instructions

Create a copy of the existing STRIVE installation directory, as following these instructions involves reinstalling STRIVE. All data in the current STRIVE directory will be lost.

Set the environment variables as shown in Table 5:

Table 5. *Environment Variables*

ENVIRONMENT VARIABLE	PURPOSE
GCCSIP	IP Address of the GCCS Computer.
GCCSPort	Port on which to receive OTH-GOLD messages.
CGF_DYNAMICS_SUBBANDING_LEVEL	1
CGF_SHIP_DYNAMICS_SUBBANDING_LEVEL	5

16. Copy the LatestChange directory from the CD overtop the existing STRIVE installation. Hit OK when prompted to overwrite existing files.

17. Open UAV SHELL and run the UAV_3_PostProcess_Specimens_phase3.bat file found in the script directory of the STRIVE install.

18. Open STRIVE Studio, Click File -> Import, and import the following files:

An AA1 Report.sfx

An AA1-AIS Report.sfx

An AIS Report.sfx

An HFSWR Report.sfx

An OSWEX Report.sfx

blank.sfx

Figure8_2KM.sfx

19. Open the blank scenario in Strive Studio and set the exercise Host and Participant Host to the local machine in the exercise properties panel.

20. Save the scenario and Exit Strive.

21. Open UAV SHELL and run gen.bat from the CD. This will create the fish and merch scenarios. One error will be generated – this is the normal behaviour.

Appendix F – STRIVE Doctrines

Doctrine: An Oth Weather Report

Rule Base: Rule Base 1

Rule Set: Rule Set 1

1.1 **IF** Variable *LastWR* is assigned = FALSE

THEN Set Variable *LastWR* = 11

1.2 **IF** Number of seconds since scenario start ≥ *LastWR*

THEN Set Variable *LastWR* = (Number of seconds since scenario start + 60)

THEN Execute Response

Category:	Communication
Type:	Send Weather Report
Parameters:	**Casting Method** = Broadcast
	Message Format = OthGold
	Transmitter Type = RealGccs Communications
	Network to Use = Current Network

1.3 Execute Response

Category:	Communication
Type:	Send Tactical Message
Parameters:	**Casting Method** = Broadcast
	Tactical Message to Send = I am in Position
	Message Format = Plain
	Transmitter Type = Basic Communications
	Network to Use = Current Network

Doctrine: Figure8_2KM

Rule Base: Rule Base 1

Rule Set: Rule Set 1

1.1 Set Variable *MaxDistance* = 2000
Set Variable *MinDistance* = 500

1.2 **IF** (Variable *Init* is assigned = TRUE AND
HeadingAwayFromStart = FALSE)
THEN Invoke Rule Set **KeepGoing**

1.3 **IF** (Variable *Init* is assigned = TRUE AND
HeadingAwayFromStart = TRUE)
THEN Invoke Rule Set **TurnAboutRule**

1.4 **IF** Variable *Init* is assigned = FALSE
THEN Set Variable *StartLocation* = Location of Self Entity
THEN Set Variable *Init* = TRUE
THEN Execute Response
Category: Navigation
Type: Navigate
Parameters: Heading Mode = Unchanged
Velocity mode = Absolute
Requested velocity = 2.06
Indicated airspeed = FALSE
Navigation mode = Contour
Requested altitude (asl) = 0
THEN Set Variable *HeadingAwayFromStart* = TRUE

Rule Set: KeepGoing

2.1 **IF** Slant Range from Self Entity to *StartLocation* <= *MinDistance*
THEN Execute Response
Category: Navigation
Type: Navigate
Parameters: Heading Mode = Unchanged
Velocity mode = Absolute

Requested velocity	= 2.06
Indicated airspeed	= FALSE
Navigation mode	= Contour
Requested altitude (asl)	= 0

THEN Set Variable *HeadingAwayFromStart* = TRUE

Rule Set: TurnAboutRule

3.1 **IF** Ground Range from Self Entity to *StartLocation* ≥ *MaxDistance*

THEN Execute Response

Category: Navigation

Type: Navigate

Parameters:

Heading Mode	= WRT Location
Requested heading	= 0.000000000000000e+000
Requested location (coordinates)	= *StartLocation*
Velocity mode	= Unchanged
Navigation mode	= Contour
Requested altitude (asl)	= 0

THEN Set Variable *HeadingAwayFromStart* = FALSE

Doctrine: An AA1 Report

Rule Base: Rule Base 1

Rule Set: Rule Set 1

1.1 **IF** Variable *LastReport* is assigned = FALSE

THEN Set Variable *LastReport* = 0

1.2 **IF** Number of seconds since scenario start ≥ *LastReport*

THEN Execute Response

Category: Communication

Type: Send AA1 Report

Parameters:

Casting Method	= Broadcast
Situation to Report	= Self Entity
Message Format	= OthGold
Transmitter Type	= RealGccs Communications
Network to Use	= Current Network

THEN Set Variable *LastReport* = (Number of seconds since scenario start + 60)

1.3 Execute Response

Category: Communication

Type: Send Tactical Message

Parameters:

Casting Method	= Broadcast
Tactical Message to Send	= I am in Position
Message Format	= Plain
Transmitter Type	= Basic Communications
Network to Use	= Current Network

Doctrine: An AIS Report

Rule Base: Rule Base 1

Rule Set: Rule Set 1

1.1 **IF** Variable *LastReport* is assigned = FALSE

THEN Set Variable *LastReport* = 0

1.2 **IF** Number of seconds since scenario start ≥ *LastReport*

THEN Execute Response

Category: Communication

Type: Send AIS Report

Parameters:

Casting Method	= Broadcast
Situation to Report	= Self Entity
Message Format	= OthGold
Transmitter Type	= RealGccs Communications
Network to Use	= Current Network

THEN Set Variable *LastReport* = (Number of seconds since scenario start + 60)

1.3 Execute Response

Category: Communication

Type: Send Tactical Message

Parameters:

Casting Method	= Broadcast
Tactical Message to Send	= I am in Position
Message Format	= Plain
Transmitter Type	= Basic Communications
Network to Use	= Current Network

Doctrine: An AA1-AIS Report

Rule Base: Rule Base 1

Rule Set: Rule Set 1

1.1 **IF** Variable *LastAis* is assigned = FALSE

THEN Set Variable *LastAis* = 1
THEN Set Variable *LastAa1* = 3

1.2 **IF** Number of seconds since scenario start ≥ *LastAa1*

THEN Execute Response

Category: Communication
Type: Send AA1 Report
Parameters:

Casting Method	= Broadcast
Situation to Report	= Self Entity
Message Format	= OthGold
Transmitter Type	= RealGccs Communications
Network to Use	= Current Network

THEN Set Variable *LastAa1* = (Number of seconds since scenario start + 46)

1.3 **IF** Number of seconds since scenario start ≥ *LastAis*

THEN Execute Response

Category: Communication
Type: Send AIS Report
Parameters:

Casting Method	= Broadcast
Situation to Report	= Self Entity
Message Format	= OthGold
Transmitter Type	= RealGccs Communications
Network to Use	= Current Network

THEN Set Variable *LastAis* = (Number of seconds since scenario start + 37)

1.4 Execute Response

Category: Communication
Type: Send Tactical Message
Parameters:

Casting Method	= Broadcast
Tactical Message to Send	= I am in Position
Message Format	= Plain
Transmitter Type	= Basic Communications
Network to Use	= Current Network

Doctrine: An HFSWR Report

Rule Base: Rule Base 1

Rule Set: Rule Set 1

1.1 **IF** Variable *LastReport* is assigned = FALSE

THEN Set Variable *LastReport* = 0

THEN Execute Response

Category: Radar

Type: Set Radar Mode

Parameters: Radar Mode for all radars = Search

1.2 **IF** Number of seconds since scenario start ≥ *LastReport*

THEN Execute Response

Category: Communication

Type: Send HFSWR Report

Parameters:
Casting Method = Broadcast
Contact to Report = Self Entity
Message Format = OthGold
Transmitter Type = RealGccs Communications
Network to Use = Current Network

THEN Set Variable *LastReport* = (Number of seconds since scenario start + 60)

1.3 Execute Response

Category: Communication

Type: Send Tactical Message

Parameters:
Casting Method = Broadcast
Tactical Message to Send = I am in Position
Message Format = Plain
Transmitter Type = Basic Communications
Network to Use = Current Network

Appendix G - High Frequency Surface Wave Radar (HFSWR)

Because of the curvature of the earth, and the line of sight target detection for radars, low-altitude and surface targets are not detected by microwave radars. High-frequency surface wave radar (HFSWR) is a technology that is overcoming this limitation. Surface waves propagate efficiently for vertical polarization over a conducting surface. Consequently, over-the-horizon application of HFSWR is practical for coastal or shipboard installations where the ocean surface serves as the conductor. The Canadian HFSWR technology has been developed through the combined effort of scientists and engineers of DRDC Ottawa and Raytheon Canada Limited (RCL) [10].

In 2003 Canada announced the maritime security initiatives. There is a provision of a $45 M funding to procure a network of HFSWR that oversees the east and west coasts. On the east coast, DND has built two High Frequency Surface Wave Radar (HFSWR) sites that can track vessels of 3000 tons or more as far as 170 miles off the coast. One was installed at Cape Bonavista, the other at Cape Race, Newfoundland see Figure 6. This technology is seen as being at the forefront for future surveillance and tracking in Canadian off-shore waters, especially for tracking vessels which do not comply with other automatic tracking systems. The two radar facilities in Newfoundland provide an ideal proving ground for further refinements to the radar and a place to showcase the technology to potential customers [10].

The Navy considers the HFSWR's potential as very positive for enhancing the Recognized Maritime Picture (RMP) and common operating picture (COP), surveillance tools for the Canadian Forces (CF). The HFSWR provides information on low-altitude and surface targets within its surveillance area on a real-time basis. Tracks of detected targets will be sent to the Operation and Control Centre (OCC) from the radar sites via communication links. Besides providing tracks of vessels, icebergs and aircraft, the radar data is processed to extract information regarding the conditions of the ocean surface, for example, the height and direction of waves. The introduction of this new sensor promises to provide more timely surveillance data to Maritime Command. The continuous surveillance data provided by the HFSWR make it possible to associate contacts from dissimilar sensors and form composite tracks. This enhances Maritime Command's ability to manage and exploit raw sensor data [10].

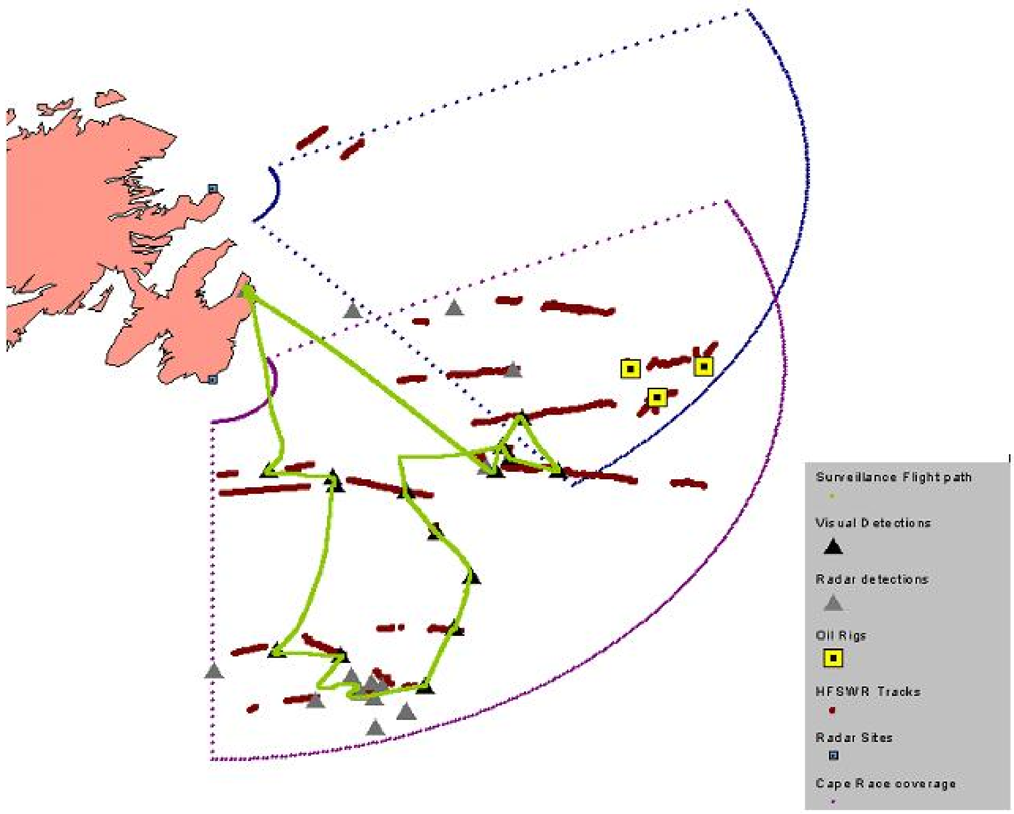

Figure 6. *HFSWR Coverage*

HFSWR MODEL SWR-1018 [9]

Implementation	Complete radar system is delivered factory-installed in ISO shelter
Configuration	Redundant receiver exciter signal data processors operating on interleaved dual frequencies with a shared fail-soft transmitter power amplified
Frequency Band	10 to 18 MHz
AC Supply	115 to 230 V 60 Hz single phase
Power Consumption	22 kVA (radar equipment operating) 36 kVA (radar equipment plus air conditioning for peak load on hottest day)
Transmitter	8 kW peak, 0.8 kW average

Power	
Occupied Bandwidth	3 to 80 kHz determined by available spectrum; typically operates at less than 20 kHz
Waveform	Stepped FM/phase
Transmit Antenna	Monopole log periodic
Receive Antenna	16-element monopole array on groundscreen
Update Rate	165 seconds typical
Doppler Resolution	0.01 Hz typical
Azimuth Resolution	6 degrees nominal; two targets will be resolved provided they are distinguishable in any one dimension
Range Resolution	4 nm nominal at 20 kHz BW
Track Accuracy	Typically better than ±0.5 nm

Appendix H - Global Command and Control System (GCCS)

GCCS is a joint mandated Command and Control (C2) automated data processing "system-of-systems" designed to support situational awareness and crisis planning with the use of an integrated set of analytic tools and flexible data transfer capabilities, see Figure 7. GCCS will be providing command and control, communications, computers and intelligence (C4I) capabilities for Marine Corps commands participating in joint planning and execution. GCCS encompasses the policies, procedures, and systems to provide information data sourcing and monitoring, planning, and executing of mobilization, deployment, employment, sustainment, redeployment, and force regeneration activities associated with command and control of military operations. The GCCS implementation approach provides an infrastructure supporting migration of selected Command and Control (C2) applications into a client/server, open system environment.

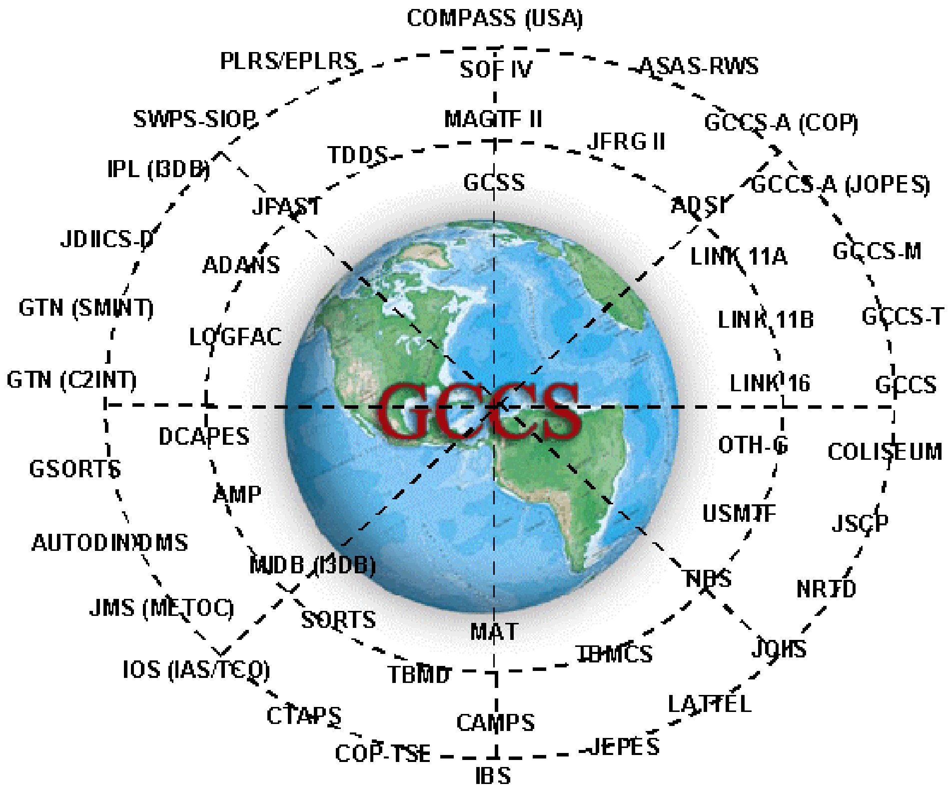

Figure 7. *Global Command and Control System*[3]

[3] From **http://www.fas.org/nuke/guide/usa/c3i/gccs.htm**

List of symbols/abbreviations/acronyms/initialisms

AIS	Automatic Identification System
ALIX	Atlantic Littoral Intelligence Surveillance Reconnaissance Experiment
AOR	Area Of Responsibility
ASuW	Antisubmarine Warfare
ASW	Anti Surface submarine Warfare
AW	Acoustic Warfare
C2	Command and Control
C4ISR	Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance
CBSA	Canadian Border Services Agency
CE	Capability Engineering
CMM	Capability Maturity Model
COE	Common Operating Environment
CTS	Commercial Traffic Server
DND	Department of National Defence
DoD	Department of Defense
DRDC	Defence Research and Development Canada
ECMSS	East Coast Maritime Sensor Suite
EEZ	Exclusive Economic Zone
ELINT	Electronic Intelligence
FFSE	Future Forces Synthetic Environments

GCCS	Global Command and Control System
GOC	Government Of Canada
HFSWR	High Frequency Surface Wave Radar
HIT	High Interest Track/Target
ISR	Intelligence Surveillance Reconnaissance
MOC	Maritime Operations Centre
MOE	Measures Of Effectiveness
MOP	Measures Of Performance
MUSIC	Multi-Sensor Integration within the Common Operating Environment
MW	Maritime Warfare
NATO	North Atlantic Treaty Organisation
NDIA	National Defense Industrial Association
OSWEX	Own-ship Weather
OTH	Over The Horizon
RAST	Radar and Application Space Technology
RCMP	Royal Canadian Mounted Police
RMP	Recognized Maritime Picture
RTB	Research Test Bed
SAR	Search And Rescue
SE	Synthetic Environment
SEI	Software Engineering Institute
STANAG	Standardisation Agreement (NATO)
STRIVE	Synthetic Tactical Real-Time Interactive Visual Environment

TDP	Technology Demonstration Project
UAV	Unmanned Aerial Vehicle

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The Future Forces Synthetic Environments (FFSE) and the Radar and Application Space Technology (RAST) Sections made a joint effort to overcome some limitations associated with the Synthetic Environment (SE) employed during the mission rehearsal, in June 2004, for the Atlantic Littoral Intelligence Surveillance Reconnaissance Experiment (ALIX). During ALIX experiment, the fidelity of the different vessels was deficient, the realism of the sensors was poor and the accuracy of the generated contact reports was incomplete. The realism and fidelity of the merchant and fishing traffic within the synthetic environment was improved. The realism of the sensors within the synthetic environment was increased. The accuracy of the generated contact reports was improved.

This document provides a summary of the achievements of the current task as well as a list of lessons learned and recommendations for organizational and process changes within the FFSE section. Based on the work accomplished in the present task, along with the recommendations, a complete maritime synthetic environment, supporting continuous V&V, for surveillance missions will soon be a reality in the FFSE section

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